REPORT

OF THE

Twentieth Annual Meeting

OF THE

South African Association

FOR THE ADVANCEMENT OF SCIENCE,

BEING VOLUME XIX OF THE

SOUTH AFRICAN JOURNAL OF SCIENCE.

LOURENÇO MARQUES

1922

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1922.

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THE

SOUTH AFRICAN JOURNAL OF SCIENCE

COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

(1922, LOURENÇO MARQUES).

Vol. XIX. **DECEMBER, 1922.** **Vol. XIX**

EDITORIAL NOTE

The attention of Members of the Association and readers is directed to the fact that, in view of the prevailing circumstances, the Council of the Association has decided that the JOURNAL shall be issued as a single volume, containing the papers recommended for publication after having been read at the Annual Meeting. The present issue is thus complete in itself, and forms Volume XIX of the Reports of the Association.

Information regarding the activities of the Association, its previous Reports and the cost of back numbers can be obtained from the Assistant General Secretary, P.O. Box 6894, Johannesburg, Transvaal.

H. B. F.

OFFICERS AND COUNCIL, 1922-23.

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HIS MAJESTY THE KING.

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Potchefstroom.

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Bloemfontein.

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F. W. Storey, B.Sc.

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Pietermaritzburg.

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Prof. R. B. Denison, D.Sc., Ph.D.
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Durban.

E. C. Chubb.
B. M. Narbeth, B.Sc.

V.—RHODESIA.

H. B. Maufe, B.A.

VI.—MOZAMBIQUE.

M. A. Peres, Jun., D.Sc.

Trustees:

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W. Runciman, M.L.A.

South Africa Medal Fund.

J. de V. Roos, B.A., LL.B.
Sir W. Thomson, M.A., B.Sc., LL.D.
W. J. Viljoen, M.A., Ph.D.

CONSTITUTION

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

[*As amended at the Twentieth Annual Meeting at Lourenço Marques,* 1922.]

I.—OBJECTS.

The objects of the Association are:—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

II.—MEMBERSHIP.

(*a*) All persons interested in the objects of the Association are eligible for Membership.

(*b*) Institutions, Societies, Government Departments and Public Bodies are eligible as "Institutional Members."

(*c*) The Association shall consist of (a) Life Members, (b) Ordinary Members (both of whom shall be included under the term "Members"), (c) Institutional Members, and (d) Temporary Members, elected for a session, hereinafter called "Associates."

(*d*) Members, Institutional Members and Associates shall be elected directly by the Council, but Associates may also be elected by Local Committees. Members may also be elected by a majority of the Members of Council resident in that centre at which the next ensuing session is to be held.

(*e*) The Council shall have the power, by a two-thirds vote, to remove the name of a Member of any class, whose Membership is no longer desirable in the interests of the Association.

(*f*) The Council shall have the power to strike off the roll of the Association the names of Members whose subscriptions are in arrears for two years, due and proper notification having been previously given.

III.—PRIVILEGES OF MEMBERS AND ASSOCIATES.

(*a*) Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association.

(*b*) Ordinary Members shall be eligible for all offices of the Association and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay, *without intermission,* their Annual Subscription.

(*c*) Institutional Members shall receive *gratuitously* all ordinary publications of the Association on the same conditions as ordinary members, and each Institutional Member shall be entitled to send one representative to the Annual Session of the Association.

(*d*) Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

(e) Members and Institutional Members may purchase from the Association (for the purpose of completing their sets) any of the Annual Reports of the Association, at a price to be fixed upon by the Council.

IV.—SUBSCRIPTIONS.

(a) Every Life Member shall pay, on admission as such, the sum of Fifteen Pounds.

(b) Ordinary and Institutional Members stall pay, on election, an Annual Subscription of One Pound Ten Shillings. Subsequent Annual Subscriptions shall be payable on the first day of July in each year.

(c) An Ordinary Member may at any time become a Life Member by one payment of Fifteen Pounds in lieu of future Annual Subscriptions. An Ordinary Member may, after ten years, provided that his subscriptions have been paid regularly without intermission, become a Life Member by one payment of Seven Pounds Ten Shillings in lieu of future Annual Subscriptions.

(d) The Subscription for Associates for a Session shall be One Pound.

V.—MEETINGS.

The Association shall meet in Session annually. The place of meeting shall be appointed by the Council as far in advance as possible, and the arrangements for it shall be entrusted to the Local Committee, in conjunction with the Council.

VI.—COUNCIL.

(a) The Management of the affairs of the Association shall be entrusted to a Council, five to form a quorum.

(b) The Council shall consist of the President, Retiring President, four Vice-Presidents, two General Secretaries, General Treasurer, the Editor of the Publications of the Association, and the Librarian, together with one Member of Council for every twenty Members of the Association.

(c) The President, Vice-Presidents, General Secretaries, General Treasurer, the Editor of the Publications of the Association and the Librarian shall be nominated at a meeting of Council not later than two months previous to the Annual Session, and shall be elected at the Annual General Meeting.

(d) Ordinary Members of Council to represent centres having more than twenty Members shall, not later than one month prior to the Annual Session of the Association, be elected by each such Centre, in the proportion of one representative for every twenty Members. The Annual General Meeting shall elect other Ordinary Members of Council, in number so as to give, together with the Members of Council already elected by the Centres, in all, one Member of Council for every twenty Members of the Association.

(e) The Council shall have the power to co-opt Members, not exceeding five in number, from among the Members of the Association resident in that Centre at which the next Session is to be held.

(f) In the event of a vacancy occuring in the Council, or among the Officers of the Association, in the intervals between the Annual Sessions, or in the event of the Annual Meeting leaving vacancies, the Council shall have the power to fill such vacancies.

(g) During any Session of the Association the Council shall meet at least twice, and the Council shall meet at least six times during the year, in addition to such meetings as may be necessary during the Annual Session of the Association.

(h) The Council shall have the power to pay for the services of Assistant General Secretaries for such clerical assistance as it may consider necessary, and for such assistance as may be needed for the publication of the Association Report or Journal.

(i) The Council shall have power to frame Bye-laws to facilitate the practical working of the Association, so long as these Bye-laws are not at variance with the Constitution.

VII.—LOCAL AND RECEPTION COMMITTEES.

(*a*) A Local Committee shall be constituted for the Centre at which the Annual Session is to be held, and shall consist of the Members of the Council resident in that Centre, with such other Members of the Association as the said Members of Council may elect.

(*b*) The Local Committee shall form a Reception Committee to assist in making arrangements for the reception and entertainment of visitors. Such Reception Committee may include persons not necessarily Members or Associates of the Association.*

(*c*) The Local Committee shall be responsible for all expenses in connection with the Annual Session of the Association.

VIII.—HEADQUARTERS.

The Headquarters of the Association shall be in Johannesburg.

IX.—FINANCE.

(*a*) The Financial Year shall end on the 31st of May.

(*b*) All sums received for Life Subscriptions and for Entrance Fees shall be invested in the names of three Trustees appointed by the Council, and only the interest arising from such investment shall be applied to the uses of the Association, except by resolution of a General Meeting; provided that any composition fee as a Life Member paid over to the Trustees of the Endowment Fund after the 30th day of May, 1914, may, upon the death of such Member, be repaid by the Trustees to the General Account of the Association, if the Council shall so decide.

(*c*) The Local Committee of the Centre in which the next ensuing Session is to be held shall have the power to expend money collected, or otherwise obtained in that Centre, other than the subscriptions of Members. Such disbursements shall be audited, and the financial statement and the surplus funds forwarded to the General Treasurer within one month after the Annual Session.

(*d*) All cheques shall be signed by the General Treasurer and a General Secretary, or by such other person or persons as may be authorised by the Council.

(*e*) Whenever the balance in the hands of the Treasurer shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

(*f*) On the request of the majority of the Members of Council of any Centre in which two or more Members of Council reside, the Council shall empower the local Members of Council in that Centre to expend sums not exceeding in the aggregate 10 per centum of the amount of Annual Subscriptions raised in that Centre.

(*g*) The whole of the acounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by an auditor appointed by the Council, and the balance-sheet shall be submitted to the Council at the first meeting thereafter, and be printed in the Annual Report of the Association.

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* The Reception Committee should make arrangements to provide:—

(1) A large hall for the delivery of the Presidential Address and evening lectures.

(2) A large room to be used as a Reception Room for members and others, at which all information regarding the Association can be obtained, and which shall have attached to it two Secretaries' Offices, a Writing Room for members and others, a Smoking Room, and Ladies' Room.

(3) Six rooms, each capable of accommodating about 30 or 40 people, to be used as Sectional Meeting Rooms, and, if possible, to have rooms attached, or in close proximity, for the purpose of holding meetings of Sectional Committees.

(4) Other requirements, such as office furniture, blackboards, window blinds to darken sectional meeting rooms for Lantern lectures, notice boards, etc.

X.—SECTIONS OF THE ASSOCIATION.

The Scientific Work of the Association shall be transacted under such sections as shall be constituted from time to time by the Council, and the constitution of such Sections shall be published in the Journal.

The Sections shall deal with the following Sciences and such others as the Council may add thereto from time to time:—Agriculture; Anthropology and Ethnology; Archæology; Architecture; Anatomy; Astronomy; Bacteriology; Botany; Chemistry; Education; Engineering; Eugenics; Geodesy and Surveying; Geography; Geology and Mineralogy; Irrigation; Mathematics; Mental Science; Meteorology; Philology; Physics; Physiology; Political Economy; Sanitary Science; Sociology; Statistics; Zoology.

XI.—RESEARCH COMMITTEES.

(*a*) Grants may be made by the Association to Committees or to individuals for the promotion of scientific research.

(*b*) Every proposal for special research, or for a grant of money in aid of special research shall primarily be considered by the Sectional Committee dealing with the science specially concerned, and if such proposal be approved, shall be referred to the Council.

(*c*) A Sectional Committee may recommend to Council the appointment of a Research Committee, composed of Members of the Association, to conduct research or to administer a grant in aid of research.

(*d*) In recommending the appointment of Research Committees, the Sectional Committee shall specifically name all Members of such Committees; and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The number of Members appointed to serve on a Research Committee shall be as small as is consistent with its efficient working.

(*e*) All recommendations adopted by Sectional Committees shall be forwarded without delay to the Council for consideration and decision.

(*f*) Research Committees shall be appointed for one year only, but if the work of a Research Committee cannot be completed in that year, application may be made, through a Sectional Committee, at the next Annual Session for re-appointment, with or without a grant—or a further grant—of money.

(*g*) Every Research Committee, and every individual, to whom a grant had been made, shall present to the following Annual Meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

(*h*) In each Research Committee, the Secretary thereof shall be the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

XII.—SPECIAL COMMITTEES.

The Council shall have power to appoint Special Committees to deal with such subjects as it may approve, to draft regulations for any such Committees, and to vote money to assist the Committees in their work.

XIII.—SECTIONAL COMMITTEES.

(*a*) The Sectional Committees shall consist of a President, two Vice-Presidents, two or more Secretaries, and such other persons as the Council may consider necessary, who shall be elected by the Council. Of the Secretaries, one shall act as Recorder of the Section, and at least one shall be resident in the Centre where the Annual Session is to be held.

(*b*) From the time of their election, which shall take place as soon as possible after the Session of the Association, they shall form themselves

into an organising Committee for the purpose of obtaining information upon Papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees.

(*c*) The Sectional Committees shall have power to add to their number from among the Members of the Association.

(*d*) The Committees of the several Sections shall determine the acceptance of Papers before the beginning of the Session, keeping the General Secretaries informed from time to time of their work. It is, therefore, desirable, in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an Abstract of his Paper, and he should send it, together with the original Paper, to the Secretary of the Section before which it is to be read, so that it may reach him at least a fortnight before the session.

(*e*) Members may communicate to the Sections the Papers of non-members.

(*f*) The Author of any Paper is at liberty to reserve his right of property therein.

(*g*) The Sectional Committees shall meet not later than the first day of the Session in the Rooms of their respective Sections, and prepare the programme for their Sections and forward the same to the General Secretaries for publication.

(*h*) The Council cannot guarantee the insertion of any Report, Paper or Abstract in the Annual Volume unless it be handed to the Secretary of the Section before the conclusion of the Session.

(*i*) The Sectional Committees shall report to the Council what Reports, Papers or Abstracts it is thought advisable to print, but the final decision shall rest with the Council.

XIV.—ALTERATION TO RULES.

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council and communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

During the interval between two Annual Sessions of the Association, any alterations proposed to be made in the Rules shall be valid if agreed to by two-thirds of the Members of Council. Such alteration of rules shall not be permanently incorporated in the Constitution until approved by the next Annual Meeting.

XV.—VOTING.

In voting for Members of Council, or on questions connected with Alterations to Rules, absent Members may record their vote in writing.

RULES FOR THE AWARD OF MEDALS.

A.—The South Africa Medal.

I.—Constitution of Committee.

(*a*) The Council of the South African Association for the Advancement of Science shall, annually and within three months after the close of the Annual Session, elect a Committee to be called "the South Africa Medal Committee," on which, as far as possible, every Section of the Association and each Province of South Africa shall have fair representation.

(*b*) This Committee shall consist of eight Members elected from amongst Council Members, together with four other Members, selected from amongst Members of the Association who are not on the Council.

(*c*) Each new Committee shall retain not less than four members who have served on the previous Committee.

(*d*) The Chairman of the Committee shall be appointed annually by the Council from amongst its Members.

(*e*) Any casual vacancy in the Committee shall be filled by the Council.

II.—Duties.

(*a*) The duties of the Committee shall be to administer the Income of the Fund and to award the Medal, raised in commemoration of the visit of the British Association to South Africa in 1905, in accordance with the resolution of its Council.

(*b*) This resolution read as follows :

(1) That, in accordance with the wishes of subscribers, the South Africa Medal Fund be invested in the names of the Trustees appointed by the South African Association for the Advancement of Science.

(2) That the Dies for the Medal be transferred to the Association to which, in its corporate capacity, the administration of the Fund and the award of the Medal shall be, and is hereby, entrusted, under the conditions specified in the Report to the Medal Committee.

(*c*) The terms of conveyance are as follows :

(1) That the Fund be devoted to the preparation of a Die for a Medal, to be struck in Bronze, $2\frac{1}{2}$ inches in diameter ; and that the balance be invested and the annual income held in trust.

(2) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science for achievement and promise in scientific research in South Africa.

(3) That, so far as circumstances admit, the award be made annually.

(*d*) The British Association has expressed a desire that the award shall be made only to those persons whose scientific work is likely to be usefully continued by them in the future.

III.—Awards.

(*a*) Any individual engaged in scientific research in South Africa shall be eligible to receive the award.

(*b*) The Medal and the available balance of one year's income from the Funds shall be awarded to one candidate only in each year (save in the case of joint research); to any candidate once only; and to no member of the Medal Committee.

(*c*) Nominations for the recipient of the award may be made by any Member of the South African Association for the Advancement of Science, and shall be submitted to the Medal Committee not later than six months after the close of the Annual Session.

(*d*) The Medal Committee shall recommend the recipient of the award to the Council, provided the recommendation is carried by the vote of at least a majority of three-fourths of its Members, voting verbally or by letter, and submitted to the Council at least one month prior to the Annual Session for confirmation.

(*e*) The award shall be made by the full Council of the South African Association for the Advancement of Science after considering the recommendations of the Medal Committee, provided it is carried by the vote of a majority of its Members, given in writing or verbally.

(*f*) The Council shall have the right to withhold the award in any year, and to devote the funds rendered available thereby in subsequent award or awards, provided the stipulation contained in the second term of conveyance of the British Association is adhered to.

(*g*) No alteration shall be made in these Rules except under the condition specified in Chapter XIV of the Association's Constitution, reading :—

Any proposed alteration of the Rules :—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council, and be communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

(*h*) Should a Member of the Medal Committee accept nomination for the Award or be absent from South Africa at any time within four months before the commencement of the ensuing Annual Session, he will, *ipso facto,* forfeit his seat on the Committee.

B.—The Goold-Adams Medals.*

(*a*) The Medals shall be awarded on the joint result of the Matriculation and University Senior Certificate Examination of the University of the Cape of Good Hope.

(*b*) One Medal shall be awarded to the student who has taken the highest place in each of the seven Science subjects: (1) Physics; (2) Chemistry; (3) Elementary Physical Science; (4) Botany; (5) Zoology; (6) Elementary Natural Science; and (7) Mathematics, as set forth in the University Matriculation and the University Senior Certificate Examination; and who is not over the prescribed age for Exhibitions at the Matriculation Examination.

(*c*) The standard of marks shall be not less than 65 per cent. of the maximum.

(*d*) The Medals shall be struck in bronze.

BYE-LAWS.

I.—*Bye-laws under which the O.F.S. Philosophical Society was incorporated from 1st July, 1914, with the South African Association for the Advancement of Science, with the designation of "The Orange Free State Branch" of the Association.*

1. The O.F.S. Philosophical Society to be incorporated with the South African Association for the Advancement of Science, this being the only course of procedure open under the existing Constitution.

2. The title of the Society so incorporated to be "The Orange Free State Branch of the South African Association for the Advancement of Science."

3. All members of the South African Association for the Advancement of Science resident in the Orange Free State will, for the purpose of these bye-laws, be considered members of the Orange Free State Branch of the Association.

4. The local Committee of the Branch to consist of the Council members of the Association for the Orange Free State, together with such additional members as the Branch may elect to serve on its local Committee.

5. Subscription notices to members of the Branch to be circulated from the Head Office of the Association in Johannesburg, and subscriptions to be paid to the General Treasurer of the Association at Johannesburg, 10 per cent. thereof being remitted to the Orange Free State Branch for local expenses. Subscriptions of £1 10s. per annum to entitle to membership of the Association as a whole, as well as of the Orange Free State Branch.

6. All members at present on the books of the Orange Free State Philosophical Society to be entitled to become members of the Association,

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* The award of these medals is at present suspended.

to receive its Journal, and to enjoy the full privileges of membership, as soon as their subscriptions for the financial year 1914-15 shall have been paid.

7. Papers read before the Orange Free State Branch may either (1) be printed by title, abstract, or *in extenso*, in the Journal of the Association for the current year, after reference to the Presidents of the respective Sectional Committees, or (2) be read at the next Annual Session of the Association (provided that they have not been previously published in abstract or *in extenso*), and thereafter printed in the Association's Journal, subject to the ordinary conditions.

II.—*Bye-laws for the Guidance of Sectional Officers.*

1. The attention of all Sectional Officers is directed to Chapter XIII of the Association's Constitution, relating to the Sectional Committees and their functions.

2. The President and Recorder (or Secretary) of a Section shall have power during the Annual Session to act on behalf of the Section in any matter of urgency which cannot be brought before the consideration of the whole Sectional Committee; and they shall report such action to the next meeting of the Sectional Committee.

3. The President of the Section, or, in his absence, one of the two Vice-Presidents, shall preside at all meetings of the Section or of the Sectional Committee.

4. The President of the Section is expected to prepare a Presidential Address, which shall be delivered during the Annual Session.

5. Prior to the commencement of the Session, the Recorder of each Section shall prepare a list of all papers notified to be read during the Session, and shall also keep the Assistant Secretary of the Association informed of the titles and authors of all such papers. The Assistant Secretary shall, on his part, keep the Recorder informed of all papers that may be notified to him direct.

6. When a proposal is made for the reading of a paper at a joint meeting of Sections, the President, Recorder and Secretary of each Section shall, *ex officio*, attend a meeting convened by a General Secretary to consider the same.

7. During the continuance of the Annual Session, the Local Secretary of each Section shall be responsible for the punctual transmission to the Assistant Secretary of the daily programme of his Section for early publication, and of any other recommendations adopted by the Sectional Committee; and shall at the close of the Session furnish the Assistant Secretary with a list, showing which of the papers notified for reading before the Section have been so read, and which have been taken as read, and giving the dates in either case. He shall, at the same time, indicate the recommendations of the Sectional Committee with respect to each paper, *i.e.*, whether it should be printed in full, or in abstract, or by title only.

8. Each Sectional Committee shall cause to be prepared a record of the discussion on each paper read at its meeting; and such record shall be attached to the paper and handed in with the same in terms of Clause 11 of these instructions.

9. Each Sectional Committee shall, during the continuance of the Annual Session, meet daily, unless otherwise determined, to complete the arrangements for the next day.

10. In deciding on any recommendations regarding the printing of or otherwise of a Paper submitted to it, the Sectional Committee shall consider only the merits of the paper, and not the financial condition of the Association.

11. The Local Secretary of each Section shall, at the close of each day, collect the papers that have been read and hand them to the Assistant Secretary, together with a note explaining the cause of absence of any paper not so handed over.

12. Sectional Officers shall do their utmost to ensure punctual commencement and termination of the Section's daily proceedings; and, in drafting the programme for the next day, the Committee shall endeavour to allot a specified time to the reading and discussion of each paper, in order to prevent other Sections or the Association as a whole being inconvenienced in consequence of delays.

III.—*Bye-laws for the Affiliation of Scientific and Kindred Societies.*

Philosophical and Scientific Societies, and other Associations of a kindred character may, on application to, and with the approval of the Council, affiliate with the South African Association for the Advancement of Science on the following conditions:—

1. That as a Society can only be affiliated on the approval of the Council, no minimum of membership of such Society need be specified.

2. That each Society shall pay the Association a minimum fee of £5 for a strength of 50 members or less, and a further £1 for each additional 10 or portion of 10 members.

3. That such Society shall be entitled to one copy of the South African Journal of Science for each £1 10s. paid to the Association.

4. That such Society may, if it has a strength of 50 members, be represented on the Council of the Association by its President or such other member as may be nominated for the purpose.

5. That all members of affiliated Societies may join the Association as ordinary members, with full privileges.

6. That affiliated Societies shall be asked to take into consideration the admission of members of the Association into their Societies at a reduced subscription.

7. That papers contributed to affiliated Societies may, on recommendation of both their own Council and that of the Association, be printed in the Association's Journal of Science, after which the authors shall be entitled to reprints on the usual terms.

Table showing the Places and Dates of Meeting of the South African Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

Presidents:	Vice-Presidents:	Local Secretaries:
Sir DAVID GILL, K.C.B., LL.D., F.R.S., F.R.S.E. Cape Town, April 27, 1903.	S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Sir Charles Metcalfe, Bart., M.I.C.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S.
Sir CHARLES METCALFE, Bart., M.I.C.E. Johannesburg, April 4, 1904.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	T. Reunert, M.I.C.E., M.I.M.E.
THEODORE REUNERT, M.I.C.E., M.I.M.E. Johannesburg, August 28, 1905.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M.A.	W. Cullen.
GARDNER F. WILLIAMS, M.A. Kimberley, July 9, 1906.	J. Burtt-Davy, F.L.S., F.R.G.S. James Hyslop, D.S.O., M.B., C.M. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	W. M. Wallace, A.R.C.S., A.M.I.C.E.
JAMES HYSLOP, D.S.O., M.B., C.M. Durban, July 16, 1907.	J. Burtt-Davy, F.L.S., F.R.G.S. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	C. W. P. Douglas le Fenzi.
H.E. Hon. Sir WALTER HELY-HUTCHINSON, G.C.M.G., LL.D. Grahamstown, July 6, 1908.	Prof. J. C. Beattie, D.Sc., F.R.S.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S. Ernest Williams, A.M.I.C.E., M.I.M.M.	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Hammond Tooke.
H.E. Sir HAMILTON GOOLD-ADAMS, G.C.M.G., C.B. Bloemfontein, September 27, 1909.	J. Burtt-Davy, F.L.S., F.R.G.S. Hugh Gunn, M.A. R. Marloth, M.A., Ph.D. Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Prof. G. Potts, M.Sc., Ph.D. A. Stead, B.Sc., F.C.S.
THOMAS MUIR, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Cape Town, October 31, 1910.	W. Cullen Hugh Gunn, M.A. Prof. P. D. Hahn, M.A., Ph.D. J. M. P. Muirhead, F.S.S., F.R.S.E.	C. F. Juritz, M.A., D.Sc., F.I.C.
Professor PAUL DANIEL HAHN, M.A., Ph.D. Bulawayo, July 3, 1911.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. C. W. Howard, B.A., F.E.S. A. J. C. Molyneux, F.G.S., F.R.G.S. A. Theiler, C.M.G.	G. N. Bromehead.

Presidents:	Vice-Presidents:	Local Secretaries:
ARNOLD THEILER, C.M.G., D.Sc. Port Elizabeth, July 1, 1912.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. J. Moir, M.A., D.Sc., F.C.S. A. J. C. Molyneux, F.G.S., F.R.G.S. W. Arnott	E. G. Bryant, B.A., B.Sc.
ALEXANDER W. ROBERTS, D.Sc., F.R.A.S., F.R.S.E. Lourenço Marques, July 7, 1913.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. R. T. A. Innes, F.R.A.S., F.R.S.E. A. J. C. Molyneux, F.G.S., F.R.G.S. J. H. von Hafe	H. E. Wood, M.Sc., F.R.Met.S.
Professor RUDOLF MARLOTH, M.A., Ph.D. Kimberley, July 6, 1914.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. S. Evans W. Johnson, L.R.C.P., L.R.C.S. A. F. Williams, B.Sc.	A. F. Williams, B.Sc. F. Harrison.
ROBERT T. A. INNES, F.R.A.S., F.R.S.E. Pretoria, July 5, 1915.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. G. W. Herdman, M.A., M.I.C.E. Sir Arnold Theiler, K.C.M.G., D.Sc. A. H. Watkins, M.D., M.R.C.S., M.L.A.	E. Hope Jones.
Professor LAWRENCE CRAWFORD, M.A., D.Sc., F.R.S.E. Maritzburg, July 3, 1916.	Rev. W. Flint, D.D. Lieut.-Col. J. Hyslop, D.S.O., M.B., C.M. Prof. J. Orr, B.Sc., M.I.C.E. Sir Arnold Theiler, K.C.M.G., D.Sc.	Prof. W. N. Roseveare, M.A.
Professor JOHN ORR, B.Sc., M.I.C.E., M.I.Mech.E. Stellenbosch, July 2, 1917	A. H. Reid, F.R.I.B.A., F.R.San.I. Prof. W. N. Roseveare, M.A. Prof. E. H. L. Schwarz, A.R.C.S., F.G.S. H. E. Wood, M.Sc., F.R.Met.S.	Prof. B. de St. J. van der Riet, M.A., Ph.D.
CHARLES F. JURITZ, M.A., D.Sc., F.I.C. Johannesburg, July 8, 1918.	W. Ingham, M.I.C.E., M.I.M.E. A. H. Reid, F.R.I.B.A., F.R.San.I. Prof. W. N. Roseveare, M.A. H. E. Wood, M.Sc., F.R.Met.S.	J. A. Foote, F.G.S., F.E.I.S.
Rev. WILLIAM FLINT, D.D. Kingwilliamstown, July 7, 1919.	P. Cazalet, M.I.M.M. Prof. J. E. Duerden, M.Sc., Ph.D. W. Ingham, M.I.C.E., M.I.M.E. Prof. E. Warren, D.Sc.	F. A. O. Pym.
ILLTYD BULLER POLE EVANS, M.A., D.Sc., F.L.S. Bulawayo, July 14, 1920.	Prof. J. W. Bews, M.A., D.Sc. Prof. J. E. Duerden, M.Sc., Ph.D. Prof. R. Leslie, M.A., F.S.S. Prof. J. A. Wilkinson, M.A., F.C.S.	D. Niven.
Professor J. E. DUERDEN, M.Sc., Ph.D., A.R.C.S. Durban, July 11, 1921.	Prof. G. E. Cory, M.A., D.Lit. Prof. R. Leslie, M.A., F.S.S. T. R. Sim, D.Sc. Prof. J. A. Wilkinson, M.A., F.C.S.	P. A. van der Bijl, M.A., D.Sc., F.L.S.
ARTHUR W. ROGERS, Sc.D., M.A., F.R.S. Lourenço Marques, July 10, 1922	Prof. A. Brown, M.A., B.Sc. Prof. R. B. Denison, D.Sc., Ph.D. E. Farrar. Prof. T. M. Forsyth, M.A., Ph.D.	M. A. Peres, D.Sc.

Presidents and Secretaries of the Sections of the Association.

SECTION A.—ASTRONOMY, CHEMISTRY, MATHEMATICS, METEOROLOGY AND PHYSICS.

Date and Place.	Presidents.	Secretaries.
1903. Cape Town ...	Prof. P. D. Hahn, M.A., Ph.D.	Prof. L. Crawford.
1904. Johannesburg*	J. R. Williams, M.I.M.M., M.Amer.I.M.E.	W. Cullen, R. T. A. Innes.
1906. Kimberley ...	J. R. Sutton, M.A.	W. Gasson, A. H. J. Bourne.
1907. Natal†	E. N. Neville, F.R.S., F.R.A.S., F.C.S.	D. P. Peid, G. S. Bishop.
1908. Grahamstown ...	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	D. Williams, G. S. Bishop.

ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND IRRIGATION.

1909. Bloemfontein ...	Prof. W. A. D. Rudge, M.A.	H. B. Austin, F. Masey.
1910. Cape Town‡ ...	Prof. J. C. Beattie, D.Sc., F.R.S.E.	A. H. Reid, F. Flowers.
1911. Bulawayo ...	Rev. E. Goetz, S.J., M.A., F.R.A.S.	A. H. Reid, Rev. S. S. Dornan.
1912. Port Elizabeth...	H. J. Holder, M.I.E.E.	A. H. Reid.
1913. Lourenço Marques...	J. H. von Hafe.	Prof. J. Orr, J. Vafi Gomes.
1914. Kimberley ...	Prof. A. Ogg, M.A., B.Sc., Ph.D.	Prof. A. Brown, A. E. H Dinham-Peren.
1915. Pretoria	F. E. Kanthack, M.I.C.E., M.I.M.E.	Prof. A. Brown, J. L. Soutter.
1916. Maritzburg ...	Prof. J. Orr, B.Sc., M.I.C.E.	Prof. A. Brown, P. Mesham.
1917. Stellenbosch ...	Prof. W. N. Roseveare, M.A.	Prof. A. Brown, L. Simons.
1918. Johannesburg ...	Prof. J. T. Morrison, M.A., B.Sc., F.R.S.E.	Prof. A. Brown, Prof. J. P. Dalton.
1919. Kingwilliamstown	W. Ingham, M.I.C.E., M.I.M.E.	Dr. J. Lunt, T. G. Caink, J. Powell.
1920. Bulawayo ...	H. E. Wood, M.Sc., F.R.A.S.	Prof. J. Orr, A. C. Jennings.
1921. Durban	J. Lunt, D.Sc.	Prof. J. Orr, H. Clark.
1922. Lourenço Marques...	M. A. Peres, D.Sc.	Prof. J. Orr, R. H. Fox.

SECTION B.—ANTHROPOLOGY, ETHNOLOGY, BACTERIOLOGY, BOTANY, GEOGRAPHY, GEOLOGY, MINERALOGY AND ZOOLOGY.

1903. Cape Town ...	R. Marloth, M.A., Ph.D.	Prof. A. Dendy.
1904. Johannesburg ...	G. S. Corstorphine, B.Sc., Ph.D., F.G.S.	Dr. W. C. C. Pakes, W. H. Jollyman.
1906. Kimberley ...	Thos. Quentrall, M.I.M.E., F.G.S.	C. E. Addams, H. Simpson.

CHEMISTRY, METALLURGY, MINERALOGY, ENGINEERING, MINING AND ARCHITECTURE.

1907. Natal	C. W. Methven, M.I.C.E., F.R.S.E., F.R.I.B.A.	R. G. Kirkby, W. Paton.
1908. Grahamstown ...	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	Prof. G. E. Cory, R. W. Newman, J. Muller.

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* Metallurgy added in 1904.

† Geography and Geodesy transferred to Section A and Chemistry and Metallurgy to Section B in 1907.

‡ Irrigation added in 1910 and Geography transferred to Section B.

Date and Place.		Presidents.	Secretaries.

CHEMISTRY, BACTERIOLOGY, GEOLOGY, BOTANY, MINERALOGY, ZOOLOGY, AGRICULTURE, FORESTRY, SANITARY SCIENCE.

1909.	Bloemfontein ...	C. F. Juritz, M.A., D.Sc., F.I.C.	Dr. G. Potts, A. Stead.

CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

1910.	Cape Town ...	A. W. Rogers, M.A., Sc.D., F.G.S.	J. G. Rose, G. F. Ayers.
1911.	Bulawayo ...	A. J. C. Molyneux, F.G.S., F.R.G.S.	J. G. Rose, G. N. Blackshaw.
1912.	Port Elizabeth...	Prof. B. de St. J. van der Riet, M.A., Ph.D.	J. G. Rose, J. E. Devlin.
1913.	Lourenço Marques...	Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S.	Prof. G. H. Stanley, Captain A. Graça.
1914.	Kimberley ...	Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.	J. G. Rose, J. Parry.
1915.	Pretoria	H. Kynaston, M.A., F.G.S.	Dr. H. C. J. Tietz, Prof. D. F. du Toit Malherbe.
1916.	Maritzburg ...	Prof. J. A. Wilkinson, M.A., F.C.S.	Dr. H. C. J. Tietz, Prof. J. W. Bews.
1917.	Stellenbosch ...	Prof. M. M. Rindl, Ing.D.	Dr. H. C. J. Teitz, Prof. B. de St. J. van der Reit.
1918.	Johannesburg ...	P. A. Wagner, Ing.D., B.Sc.	Dr. H. C. J. Teitz, Dr. J. Moir.
1919.	Kingwilliamstown	H. H. Green, D.Sc., F.C.S.	Prof. J. A. Wilkinson, T. H. Harrison, W. G. Chubb.
1920.	Bulawayo ...	F. P. Mennell, F.G.S., M.I.M.M.	J. M. Hutcheon, A. M. MacGregor.
1921.	Durban	J. Moir, M.A., D.Sc., F.I.C.	Prof. J. A. Wilkinson, A. Kloot.
1922.	Lourenço Marques...	E. T. Mellor, D.Sc., F.G.S.	J. H. Wellington.

SECTION C.—AGRICULTURE, ARCHITECTURE, ENGINEERING, GEODESY, SURVEYING AND SANITARY SCIENCE.

1903.	Cape Town ...	Sir Charles Metcalfe, Bart., M.I.C.E.	A. H. Reid.
1904.	Johannesburg*...	Lieut.-Colonel Sir Percy G. Girouard, K.C.M.G., D.S.O.	G. S. Burt Andrews, E. J. Laschinger.
1906.	Kimberley ...	S. J. Jennings, C.E., M.Amer.I.M.E., M.I.M.E.	D. W. Greatbach, W. Newdigate.

BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE AND FORESTRY, PHYSIOLOGY, HYGIENE.

1907.	Natal	Lieut.-Col. H. Watkins-Pitchford, F.R.C.V.S.	W. A. Squire, A. M. Neilson, Dr. J. E. Duerden.
1908.	Grahamstown ...	Prof. S. Schönland, M.A., Ph.D., F.L.S., C.M.Z.S.	Dr. J. Bruce Bays, W. Robertson, C. W. Mally, Dr. L. H. Gough.
1910.	Cape Town† ...	Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.	W. D. Severn, Dr. J. W. B. Gunning.
1911.	Bulawayo ...	F. Eyles, F.L.S., M.L.C.	W. T. Saxton, H. G. Mundy.
1912.	Port Elizabeth...	F. W. FitzSimons, F.Z.S., F.R.M.S.	W. T. Saxton, L. L. Drège.
1913.	Lourenço Marques...	A. L. M. Bonn, C.E.	F. Flowers, Lieut. J. B. Bothelho.
1914.	Kimberley ...	Prof. G. Potts, M.Sc., Ph.D.	C. W. Mally, W. J. Calder.
1915.	Pretoria	C. P. Lounsbury, B.Sc., F.E.S.	C. W. Mally, A. K. Haagner.
1916.	Maritzburg ...	I. B. Pole Evans, M.A., B.Sc., F.L.S.	C. W. Mally, Prof. E. Warren.
1917.	Stellenbosch ...	J. Burtt-Davey, F.L.S., F.R.G.S.	C. W. Mally, C. S. Grobbelaar.

* Forestry added in 1904.

† Sanitary Science added in 1910.

Date and Place.	Presidents.	Secretaries.

BOTANY, BACTERIOLOGY, AGRICULTURE AND FORESTRY.

1918. Johannesburg ...	C. E. Legat, B.Sc.	Dr. E. P. Phillips, J. Burtt-Davy.
1919. Kingwilliamstown	Ethel M. Doidge, M.A., D.Sc., F.L.S.	Dr. E. P. Phillips, E. W. Dwyer, Dr. G. Rattray.
1920. Bulawayo ...	T. R. Sim, D.Sc., F.L.S.	Dr. E. P. Phillips, Prof. H. A. Wager.
1921. Durban	Prof. J. W. Bews, M.A., D.Sc.	Prof. H. A. Wager, Dr. H. F. Standing.
1922. Lourenço Marques...	Prof. D. Thoday, M.A.	Prof. H. A. Wager.

SECTION D.—ZOOLOGY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

1918. Johannesburg ...	Prof. E. J. Goddard, B.A., D.Sc.	C. W. Mally, R. J. Ortlepp.
1919. Kingwilliamstown	Prof. E. Warren, D.Sc.	C. W. Mally, Dr. J. I. Brownlee, B. H. Dodd.
1920. Bulawayo ...	C. W. Mally, M.Sc., F.E.S.	Dr. Annie Porter, P. H. Taylor.
1921. Durban	Prof. H. B. Fantham, M.A., D.Sc.	Dr. Annie Porter, E. C. Chubb.
1922. Lourenço Marques...	Annie Porter, D.Sc., F.L.S.	Prof. H. B. Fantham, C. B. Hardenberg.

SECTION E.—ANTHROPOLOGY, ETHNOLOGY, ECONOMICS, SOCIOLOGY AND STATISTICS.

1908. Grahamstown ...	W. Hammond Tooke.	Prof. A. S. Kidd.

ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY, AND NATIVE SOCIOLOGY.

1917. Stellenbosch ...	Rev. N. Roberts.	Rev. E. W. H. Musselwhite, Prof. J. C. Smith.
1918. Johannesburg ...	Rev. W. A. Norton, B.A., B.Litt.	Rev. E. W. H. Musselwhite, Rev. G. Evans.
1919. Kingwilliamstown	Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.	Rev. E. W. H. Musselwhite, G. R. Spencer, M. Flemmer.
1920. Bulawayo ...	Rev. H. A. Junod.	N. H. Wilson, Rev. N. Jones.
1921. Durban	C. T. Loram, M.A., LL.B., Ph.D.	Rev. N. Roberts, P. E. Chandley.
1922. Lourenço Marques...	Senator A. W. Roberts, D.Sc.	Rev. N. Roberts, Rev. H. L. Bishop.

SECTION F.—ARCHÆOLOGY, EDUCATION, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

1903. Cape Town ...	Thomas Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	Prof. H. E. S. Fremantle.
1904. Johannesburg ...	(Sir Percy Fitzpatrick, M.L.A.), E. B. Sargant, M.A. (Acting).	Howard Pim, J. Robinson.
1906. Kimberley ...	A. H. Watkins, M.D., M.R.C.S.	E. C. Lardner-Burke, E. W. Mowbray.

ANTHROPOLOGY, ARCHÆOLOGY, ECONOMICS, EDUCATION, ETHNOLOGY, HISTORY, PSYCHOLOGY, PHILOLOGY, SOCIOLOGY AND STATISTICS.

1907. Natal	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.

ARCHÆOLOGY, EDUCATION, HISTORY, PSYCHOLOGY AND PHILOLOGY.

1908. Grahamstown ...	E. G. Gane, M.A.	Prof. W. A. Macfadyen, W. D Neilson.

ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

Date and Place.	Presidents.	Secretaries.
1909. Bloemfontein ...	Hugh Gunn, M.A.	C. G. Grant, Rev. W. A. Norton.
1910. Cape Town ...	Rev. W. Flint, D.D.	G. B. Kipps, W. E. C. Clarke.
1911. Bulawayo ...	G. Duthie, M.A., F.R.S.E.	G. B. Kipps, W. J. Shepherd.
1912. Port Elizabeth...	W. A. Way, M.A.	G. B. Kipps, E. G. Bryant.
1913. Lourenço Marques...	J. A. Foote, F.G.S.	H. Pim, J. Elvas.
1914. Kimberley ...	Prof. W. Ritchie, M.A.	Prof. R. D. Nauta, A. H. J. Bourne.
1915. Pretoria	J. E. Adamson, M.A.	Prof. R. D. Nauta, R. G. L. Austin.
1916. Maritzburg ...	M. S. Evans, C.M.G., F.Z.S.	Prof. R. D. Nauta, Prof. O. Waterhouse.

EDUCATION, HISTORY, MENTAL SCIENCE, POLITICAL ECONOMY, GENERAL SOCIOLOGY AND STATISTICS.

Date and Place.	Presidents.	Secretaries.
1917. Stellenbosch ...	Rev. B. P. J. Marchand, B.A.	Prof. R. D. Nauta, Dr. Bertha Stoneman.
1918. Johannesburg ...	Prof. T. M. Forsyth, M.A., D.Phil.	Prof. R. D. Nauta, J. Mitchell.
1919. Kingwilliamstown	Prof. R. Leslie, M.A., F.S.S.	Prof. R. D. Nauta, J. Wood, F. J. Cherrigh.
1920. Bulawayo ...	Prof. R. A. Lehfeldt, B.A., D.Sc.	J. Mitchell, B. M. Narbeth.
1921. Durban	Prof. W .A. Macfadyen, M.A., LL.D.	J. A. Foote, B. M. Narbeth.
1922. Lourenço Marques...	J. M. Moll, M.D.	Mrs. Mabel Palmer.

EVENING DISCOURSES.

Date and Place.	Lecturer.	Subject of Discourse.
1903. Cape Town ...	Prof. W. S. Logeman, B.A., L.H.C.	The Ruins of Persepolis and how the Inscriptions were read.
1904. Johannesburg ...	H. S. Hele-Shaw, LL.D., F.R.S., M.I.C.E.	Road Locomotion—Present and Future.
1906. Kimberley ...	Prof. R. A. Lehfeldt, B.A., D.Sc.	The Electrical Aspect of Chemistry.
	W. C. C. Pakes, L.R.C.P., M.R.C.S., D.P.H., F.I.C.	The Immunisation against Disease of Micro-organic Origin.
1907. Maritzburg ...	R. T. A. Innes, F.R.A.S., F.R.S.E.	Some Recent Problems in Astronomy.
Durban	Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S.	The Heroic Age of South African Geology.
1908. Grahamstown ...	Prof. G. E. Cory, M.A.	The History of the Eastern Province.
	A. Theiler, C.M.G.	Tropical and Sub-tropical Diseases of South Africa: their Causes and Propagation.
1909. Bloemfontein ...	C. F. Juritz, M.A., D.Sc., F.I.C.	Celestial Chemistry.
	W. Cullen.	Explosives: their Manufacture and Use.
Maseru	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1910. Cape Town ...	Prof. H. Bohle, M.I.E.E.	The Conquest of the Air.
1911. Bulawayo ...	J. Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.	Electoral Reform—Proportional Representation.
	W. H. Logeman, M.A.	The Gyroscope.

Date and Place.	Lecturer.	Subject of Discourse.
1912. Port Elizabeth...	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	Imperial Astronomy.
	Prof. E. J. Goddard, B.A., D.Sc.	Antarctica.
1913. Lourenço Marques..	S. Seruya.	The History of Portuguese Conquest and Discovery.
1914. Kimberley ..	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	The Kimberley Mines, their Discovery and their Relation to other Volcanic Vents in South Africa.
1915. Pretoria	E. T. Mellor, D.Sc., F.G.S., M.I.M.M.	The Gold-bearing Conglomerates of the Witwatersrand.
	C. W. Mally, M.Sc., F.E.S., F.L.S.	The House Fly under South African conditions.
1916. Maritzburg ...	C. P. Lounsbury, B.Sc., F.E.S.	Scale Insects and their Travels.
Durban	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1917. Stellenbosch .	H. E. Wood, M.Sc., F.R.Met.S.	Some Unsolved Problems of Astronomy.
	Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S.	Some Marine Animals of South Africa.
1918. Johannesburg ...	Prof. H. B. Fantham, M.A., D.Sc., A.R.C.S., F.Z.S.	Evolution and Mankind.
	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S.	Ostriches.
1919. Kingwilliamstown	Prof. E. J. Goddard, B.A., D.Sc.	The Approaching South African Antarctic Expedition.
East London ...	Prof. G. E. Cory, M.A.	Early History of Kaffraria and East London.
1920. Bulawayo ...	Prof. J. A. Wilkinson, M.A., F.C.S.	The Nitrogen Problem.
1921. Durban	A. L. du Toit, D.Sc., F.G.S.	Land Connections between the other Continents and South Africa in the Past.
1922. Lourenço Marques...	C. Graham Botha.	The Early Development of South Africa.

MEETINGS AT LOURENÇO MARQUES.

On *Monday, July* 10, 1922, at 11 a.m., the Association was officially welcomed by His Excellency the High Commissioner for Moçambique (Dr. Brito Camacho) and by His Worship the Mayor of Lourenço Marques (Dr. Elisiario Monteiro) in the large hall of the Railway Headquarters. Dr. A. W. Rogers, F.R.S., President of the Association, responded.

Previously, at 10 a.m., there had been a meeting of Council.

At 11.30 a.m., Dr. M. A. Peres delivered an address, as President of Section A, on "The Rôle of Astronomy in the Development of Science."

In the afternoon there were Sectional Meetings at the Lyceu.

At 8.15 p.m., Dr. A. W. Rogers, F.R.S., President, delivered an address on "Post Cretaceous Climates of South Africa" in the large hall of the Railway Administrative Offices, Professor J. E. Duerden presiding. (See page 1.)

The President subsequently presented the South Africa Medal to Dr. I. B. Pole Evans, C.M.G. (See page xxxiv.)

On *Tuesday, July* 11, at 9.30 a.m., Dr. E. T. Mellor delivered an address, as President of Section B, on "The Influence of Mineral Deposits in the Development of a Young Country." Sectional Meetings followed.

At 2.30 p.m., Members of the Association proceeded on visits to the Wharf and Coaling Plant or to the Campos Rodrigues Observatory

At 9.30 p.m., Members attended a Ball at the Polana Hotel.

On *Wednesday, July* 12, at 10 a.m., Professor D. Thoday, M.A., delivered an address, as President of Section C, on "Carbon Assimilation in Plants." At 11.15 a.m., Dr. Annie Porter delivered an address, as President of Section D, on "Some Modern Developments in Animal Parasitology." Sectional Meetings followed.

At 2.30 p.m., Members proceeded on visits to the Hospital Miguel Bombarda or to the Golf Competition.

On *Thursday, July* 13, at 9.30 a.m., the address by Dr. J. Marius Moll, as President of Section F, was read, the title being "Remarks on Certain Mental Disorders which may be regarded as Preventable."

At 10.30 a.m., the Twentieth Annual General Meeting was held in the Lyceu, Avenida 24 de Julho, for the Minutes of which see page xxiii.

At 2.30 p.m., the address by Senator A. W. Roberts, D.Sc., as President of Section E, was read, the title being "Certain Aspects of the Native Question."

Sectional Meetings followed, but Section C went on a botanical excursion.

At 8.15 p.m., Mr. C. Graham Botha gave a popular illustrated lecture on "The Early Development of South Africa" in the Lyceu, the President of the Association presiding.

On *Friday, July* 14, at 9.30 a.m., there was a meeting of Council. At 10.30 a.m., there was a visit to the Museum, under the guidance of Commander A. de Carvalho.

There were Sectional Meetings in the afternoon. Section C went on a botanical excursion, and there was a geological excursion to the Lebombo Mountains.

At 9 p.m., Members were entertained at a Banquet at the Polana Hotel.

On *Saturday, July* 15, at 10.30 a.m., the President and Officers of the Association paid a visit to His Excellency the High Commissioner, and expressed the thanks of the Association for the great kindness and hospitality shown to Members.

There was a zoological excursion during the morning.

At 2 p.m., Members went on an excursion on the Bay in the s.s. "Luabo."

On *Sunday, July 16*, at 8 a.m., Members went on an excursion by train to Marracuene, where a regatta on the Incomati River and native dances were held. Luncheon was provided.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES.

LOURENÇO MARQUES, 1922.

LOCAL COMMITTEE.

Chairman, Dr. Manuel Antonio Peres, Junior; Dr. Manuel Maximo Prates, Director of the Bacteriological Laboratory; Engineer Guiseppe Provay, Chief Electrical Engineer of the Port and Railways of Lourenço Marques; Engineer John Aylmer Balfour, Chief of the Irrigation Department.

RECEPTION COMMITTEE.

President, His Excellency the Mayor, Dr. Elisiario Monteiro; Lieut.-Colonel José Ricardo Pereira de Cabral, President of the Conselho de Turismo; Engineer Abel de Noronha e Andrade, Director of the Port and Railways of Lourenço Marques; Mr. Adriano Maia, President of the Chamber of Commerce; Major Ernando da Motta Marques, President of the Gremio Militar; Mr. Sam Goldsbury, President of the English Club; Mr. John A. Sawer, President of the British Club; Commandant José Cardoso, President of the Associaçao do Fomento Agricola; Dr. Antonio Roquette, President of the Associaçao dos Proprietarios; Mr. José Salvado da Costa, President da Associaçao dos Logistas. *Secretary*, Ernesto Braga.

SECTIONAL COMMITTEES.

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODOSY, SURVEYING, ENGINEERING, ARCHITECTURE and IRRIGATION.

President, Manuel Antonio Peres, Junior, D.Sc.; *Vice-Presidents*, Engineer Guiseppe Provay and Prof. H. H. Paine, M.A.; *Members*, R. T. A. Innes, F.R.A.S., F.R.S.E., Prof. W. N. Roseveare, M.A., Prof. G. A. Watermeyer, B.A., A.R.S.M., H. E. Wood, M.Sc., F.R.A.S.; *Recorder*, Prof. J. Orr, O.B.E., B.Sc.; *Secretary*, R. H. Fox, A.M.Inst.W.E.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY and GEOGRAPHY.

President, E. T. Mellor, D.Sc., M.I.M.M., F.G.S.; *Vice-Presidents*, Jas. Gray, F.I.C., and T. N. Leslie, F.G.S., F.R.Met.S.; *Members*, C. F. Juritz, M.A., D.Sc., F.I.C., J. Moir, M.A., D.Sc., F.I.C., Prof. S. J. Shand, Ph.D., D.Sc., P. A. Wagner, Ing.D., B.Sc., Prof. J. A. Wilkinson, M.A., F.C.S.; *Recorder and Secretary*, J. H. Wellington, B.A.

Section C.—BOTANY, BACTERIOLOGY, AGRICULTURE, and FORESTRY.

President, Prof. D. Thoday, M.A.; *Vice-Presidents*, Prof. C. E. Moss, M.A., D.Sc., F.L.S., and E. P. Phillips, M.A., D.Sc., F.L.S.; *Members*, Prof. J. W. Bews, M.A., D.Sc., Ethel M. Doidge, M.A., D.Sc., F.L.S., Prof. G. Potts, Ph.D., B.Sc., T. R. Sim, D.Sc., Bertha Stoneman, D.Sc., Mrs. M. G. Thoday; *Recorder and Secretary*, Prof. H. A. Wager, A.R.C.S.

Section D.—ZOOLOGY, PHYSIOLOGY, HYGIENE and SANITARY SCIENCE.

President, Annie Porter, D.Sc., F.L.S.; *Vice-Presidents*, Prof. P. J. du Toit, B.A., Ph.D., Dr. Med. Vet., and A. J. Orenstein, C.M.G., M.D.; *Members*, Prof. E. H. Cluver, M.A., M.D., F. G. Cawston, M.D., Prof. J. E. Duerden, M.Sc., Ph.D., Anna G. Newell, M.A., Ph.D., M. M. Prates, M.D., L. Soromenho, M.D., Prof. E. Warren, D.Sc.; *Recorder*, Prof. H. B. Fantham, M.A., D.Sc.; *Secretary*, C. B. Hardenberg, M.A.

Section E.—ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY and NATIVE SOCIOLOGY.

President, Senator A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.; *Vice-Presidents*, Dr. L. Bostock and H. M. Taberer, B.A.; *Members*, Rev. W. Flint, D.D., J. D. Rheinallt Jones, Prof. L. F. Maingard, D.Lit., Rev. W. A. Norton, M.A., B.Litt.; *Recorder*, Rev. Noel Roberts, M.C.; *Secretary*, Rev. H. L. Bishop.

Section F.—EDUCATION, HISTORY, MENTAL SCIENCE, POLITICAL ECONOMY, GENERAL SOCIOLOGY and STATISTICS.

President, J. Marius Moll, M.D.; *Vice-Presidents*, Sir George Cory, M.A., and Prof. W. M. Macmillan, M.A.; *Members*, C. Graham Botha, Dr. A. Barradas, J. A. Foote, F.G.S., Prof. T. M. Forsyth, M.A., Ph.D., F. S. Livie-Noble; *Recorder and Secretary*, Mrs. Mabel Palmer, M.A.

PROCEEDINGS OF THE TWENTIETH ANNUAL GENERAL MEETING OF MEMBERS, HELD IN THE LYCEU, AVENIDA 24 DE JULHO, LOURENÇO MARQUES, ON THURSDAY, JULY 13, 1922, AT 10.30 A.M.

PRESENT: Dr. A. W. Rogers, F.R.S. (President), in the Chair; Mr. J. L. Andrew, Dr. A. Barradas, Prof. J. W. Bews, Rev. H. L. Bishop, Miss S. Bosman, Mr. C. Graham Botha, Prof. E. H. Cluver, Mrs. B. G. Colby, Mr. E. A. E. Collins, Prof. J. E. Duerden, Mr. H. Engels, Mrs. K. Engels, Prof. H. B. Fantham, Dr. W. Flint, Mr. J. A. Foote, Prof. T. M. Forsyth, Mr. R. H. Fox, Miss M. Heanan, Miss J. Henderson, Mr. J. D. Rheinallt Jones, Mr. H. P. Junod, Miss F. C. Kilroe, Mrs. H. B. Kriel, Mr. W. Kupferberger, Miss E. N. Ladler, Mrs. E. Mackay, Prof. L. F. Maingard, Mr. P. H. Manners, Dr. G. Melle, Dr. E. T. Mellor, Dr. J. Moir, Advocate G. T. Morice, Prof. C. E. Moss, Dr. Anna G. Newell, Mr. R. A. Page, Mrs. Mabel Palmer, Dr. Annie Porter, Prof. G. Potts, Miss N. Reitz, Mr. J. B. Robertson, Dr. J. B. Henderson Ruthven, Mr. J. Sandground, Mr. J. D. Stevens, Mr. Frank A. Stokes, Prof. D. Thoday, Mrs. M. G. Thoday, Mr. F. G. Tyers, Miss L. H. van der Koppel, Dr. P. A. Wagner, Dr. E. Warren, Mr. J. H. Wellington, Miss M. Williamson, Prof. J. A. Wilkinson (Acting Hon. General Secretary), and H. A. G. Jefferys (Assistant General Secretary).

MINUTES.—The Minutes of the Nineteenth Annual General Meeting held at Durban on the 14th July, 1921, and printed on pp. xxii—xxiv of the Report of the Durban Session (vol. xviii, Nos. 1 and 2 of the JOURNAL were confirmed.

ANNUAL REPORT OF COUNCIL.—The Annual Report of the Council for 1921-22 having been placed on the notice board in the Hall of the Lyceu for some days was taken as read and adopted. This Report will be found on p. xxvii of this issue.

REPORT OF THE HON. GENERAL TREASURER AND STATEMENTS OF ACCOUNTS FOR 1921-22.—The Hon. General Treasurer's Report and Financial Statements for 1921-22, which had been placed on the notice board in the Hall of the Lyceu for some days, were taken as read and adopted. (See pp. xxx—xxxiii of this issue). Dr. Flint congratulated the Hon. General Treasurer on being able to produce such an excellent balance sheet. Mr. T. N. Leslie stated that the favourable position in which the Association found itself was due to the generosity of the Durban firms, who so kindly contributed towards the production of the Durban number of the Journal, and proposed that the names of these firms and the donation received from each should be published in the Journal. Also that letters of thanks should be addressed to each firm and also to the Union Department of Education for their generous support. This resolution was carried unanimously.

The names of the firms are:—

A. H. Smith, Esq.	£50	0	0
Messrs. Randles Bros. & Hudson	£25	0	0
Messrs. S. Butcher & Son	£25	0	0
Messrs. Natal Cane By-Products, Ltd.	£25	0	0
Messrs. Hunt, Leuchars & Hepburn	£25	0	0
Messrs. D. Fowler & Co.	£25	0	0
Messrs. W. Dunn & Co.	£25	0	0
Messrs. Parker, Wood & Co.	£25	0	0
Messrs. W. G. Brown & Co.	£25	0	0
Messrs. Natal Estates, Ltd.	£25	0	0
Messrs. John Orr & Co.	£21	0	0
Messrs. Harvey, Greenacre & Co.	£21	0	0
Messrs. Dundee Coal Co.	£12	12	0
Messrs. Natal Navigation Colliery	£12	12	0

Messrs. Henwood, Son, Soutter & Co.	£10 0 0
Sir L. Hulett	£10 0 0
Messrs. Linder Bros.	£5 5 0
Messrs. Garlick & Co.	£5 5 0
Messrs. Enyati Colliery	£5 5 0
Messrs. Buffalo Colliery	£5 5 0
Messrs. Natal Cambrian Colliery	£3 3 0
Messrs. Newcastle Colliery	£2 2 0
J. F. Williams, Esq.	£2 2 0
Balance, after paying local expenses, of amount collected from local residents, per Durban Committee	£235 1 7

Tenders for Printing.—The Committee, consisting of Dr. Flint, Professors Duerden and Fantham, reported that they had carefully considered the letter from the Hon. General Treasurer and the tenders received from the various firms, six in number, and unanimously recommended that the tender of the Argus Printing and Publishing Company, Johannesburg, be accepted. This was confirmed.

Election of Officers for 1922-23.—

President: Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S.

Vice-Presidents: Mr. C. W. Mally, M.Sc., F.L.S., F.E.S.
Dr. S. G. Campbell, M.D., M.Ch., M.R.C.S., D.P.H.
Prof. T. M. Forsyth, M.A., Ph.D.
Mr. J. A. Foote, F.G.S., F.E.I.S.

Hon. General Secretaries:

Dr. C. F. Juritz, M.A., F.I.C.
Mr. H. E. Wood, M.Sc., F.R.A.S., F.R.Met.S.

Hon. General Treasurer: Mr. Jas. Gray, F.I.C.

Hon. Editor of Publications: Prof. H. B. Fantham, M.A., D.Sc., F.Z.S.

Hon. Librarian: Dr. Annie Porter, D.Sc., F.L.S.

Election of Trustees.—The Chairman proposed that the present trustees of the Endowment Fund and the South Africa Medal Fund be re-elected. There ensued considerable discussion as to whether such an election was necessary. It was stated that the Constitution did not define the position or duties of this office and the Council had taken high legal opinion which was to the effect that an election ought to take place periodically. Also that the Council was of the opinion that in taking such action there was no reflection whatsoever on the gentlemen who had so kindly and willingly undertaken these offices, to whom they expressed their deep gratitude for their excellent stewardship of the funds, and trusted they would be able to give the Association the benefit of their services for many years yet to come. Mr. T. N. Leslie stated that he was of the opinion that the Constitution should specifically define the position. As a result of the discussion it was proposed: "That the *status quo* hold good for another year and that the matter be brought up at the next Annual General Meeting, due notice having been given." This was unanimously agreed to.

Election of Council Members for 1922-23.—

I. Transvaal.—D. M. Burton, M.S.A., J. F. Ferreira, W. Ingham, M.I.C.E., M.I.Mech.E., R. T. A. Innes, D.Sc., F.R.A.S., F.R.S.E., J. D. R. Jones, T. N. Leslie, F.G.S., F.R.Met.S., Sir F. S. Lister, M.R.C.S., L.R.C.P., Prof. L. F. Maingard, M.A., D.Lit., Dr. E. T. Mellor, D.Sc., Dr. J. McCrae, Ph.D., F.I.C., Dr. J. Moir, M.A., D.Sc., F.I.C., Dr. J. M. Moll, M.D., Advocate G. T. Morice, K.C., Dr. A. J. Orenstein, C.M.G., M.R.C.S., Prof. J. Orr, O.B.E., B.Sc., M.I.C.E., Rev. Noel Roberts, M.C., Prof. J. A. Wilkinson, M.A., Prof. H. H. Green, D.Sc., Prof. W. A. Macfadyen, M.A., LL.D., Prof. H. A. Wager, A.R.C.S., Dr. B. de C. Marchand, D.Sc., F. G. Tyers, M.A.

II. Cape Province.—C. Graham Botha, Prof. L. Crawford, M.A., D.Sc., Rev. W. Flint, D.D., Prof. R. Leslie, M.A., J. Lunt, D.Sc., F.I.C., Prof. J. E. Duerden, M.Sc., Ph.D., F. W. Fitzsimons, F.Z.S., F.R.M.S., Miss M. Wilman, J. Leighton, F.R.H.S., Prof. P. A. van der Bijl, M.A., D.Sc., F.L.S., Miss Bertha Stoneman, D.Sc., Prof. B. de St. J. van der Riet, M.A., Ph.D.

III. Natal.—Prof. J. W. Bews, M.A., D.Sc., Prof. E. Warren, D.Sc., B. M. Narbeth, B.Sc., E. C. Chubb, F.Z.S., Prof. R. B. Denison, Ph.D., D.Sc.

IV. Orange Free State.—Prof. G. Potts, B.Sc., Ph.D., F. W. Storey, B.Sc., F.C.S.

V. Rhodesia.—Rev. E. Goetz, S.J., M.A., H. B. Maufe, B.A., F.G.S.

VI. Mozambique.—Dr. M. A. Peres, Jun., D.Sc.

Annual Session, 1923.—The President announced that an invitation from the Mayor of Bloemfontein for the Association to hold its Annual Session in that city in 1923 had been received and the letter was read by the Acting Hon. General Secretary. Discussion ensued and the opinion was expressed that the Council should consider changing the time of the meeting from July to Easter or Michaelmas, and also that the Session should be arranged in order to meet the convenience of the members of staff of all the Universities in the country. It was finally decided to refer the matter to the Council with power to act, and with a request to consider the points raised in the discussion.

It was also proposed and unanimously decided that "the Council consider the advisability of meeting at an early convenient date in the South-West Africa Protectorate, and also the advisability of sending an invitation to the British Association to meet in South Africa at an early convenient date."

Additional Clause in the Constitution.—The following motion, of which due notice had been given by the Hon. General Treasurer in February last, was proposed by the Acting Hon. General Secretary that "The Council shall have the power to strike off the roll of the Association the names of members, whose subscriptions are in arrears for two years, due and proper notification having been previously given."

An amendment by Mr. Collins, seconded by Mr. Frank A. Stokes, to the effect that "Any member who shall be in arrears with subscriptions for two years shall *ipso facto* cease to be a member, but that the Council after due consideration shall have power to reinstate such members" was put to the meeting and negatived.

The original motion was then put and confirmed.

Proposed Local Centre at Windhoek.—The question of establishing a local centre at Windhoek and admitting residents of German extraction as members, which had been referred to this meeting by the Council, was discussed briefly until Mr. T. N. Leslie moved the previous question, which was then put and carried unanimously.

Publication of the Journal.—The President announced that the Council had decided unanimously at its last meeting, in view of the prevailing circumstances, to issue the *South African Journal of Science*, containing the papers read at the meeting, in one volume as soon as conveniently possible.

Presentation of Papers in Afrikaans.—Prof. G. Potts stated in a letter to the Council that it would be of advantage to the Association that papers should be accepted in both languages. The President, in reply, stated that the Council would at all times be only too happy to receive such papers and that the Constitution did not, as some had undoubtedly

but quite mistakenly believed, prohibit papers in this language. He desired to extend a welcome to such papers on behalf of the Council, and hoped that many would be forthcoming at their next meeting.

The question raised by Prof. Potts of joint meetings of the various Sections on problems of common interest was briefly discussed, and it was pointed out that the Council had considered this some years ago and had held such meetings at former Sessions at the request of members, and, further, the point was raised in Circular No. 2, Page 5, under the heading of "Papers." The President thanked Prof. Potts and stated that he hoped that members would assist the Council in this regard.

LETTER FROM MR. A. K. HAAGNER, HON. D.SC.—This communication raised the question of the establishment of a National Park and Game Reserve in the Union of South Africa. The draft of a proposed Parliamentary Bill was also submitted. It was proposed and carried unanimously that the matter be referred to the Committee of Section D for report to the Council.

VOTES OF THANKS.—The President proposed that a very hearty vote of thanks be passed to Dr. W. Flint and Mr. C. Graham Botha, who had so kindly acted during the meeting as Presidents of Sections E and F respectively, in the unavoidable absence of Senator the Hon. A. W. Roberts and Dr. J. M. Moll. He felt sure that the members would be very willing to accord this vote on account of the excellent and energetic manner in which these gentlemen had carried out their arduous duties, for which they were so greatly indebted. The vote was carried with acclamation. Dr. Flint, in returning thanks, stated that he felt that the thanks of the Association were equally due to the Rev. H. L. Bishop who, in the absence of the Recorder of Section E, had ably discharged the secretarial duties of the Section.

A vote of thanks to the Officers of the Association for their able services during the year was also proposed by the President and carried unanimously.

The President further proposed that a hearty vote of thanks be accorded to Prof. Wilkinson for the services he had rendered in connection with the meeting, in the unavoidable absence of both Hon. General Secretaries. This was carried with acclamation.

On the motion of Mr J. A. Foote, it was carried with acclamation that the thanks of the Association be accorded to the following :—

His Excellency the High Commissioner of the Province of Moçambique.

His Worship the Mayor, Dr. Elisiario Monteiro.

The members of the Local Committee and the Reception Committee for their excellent arrangements for the meeting.

The Rector and Governors of the Lyceu and their staff for the use of their building and willing assistance.

The Director and Medical Staff of the Hospital for their reception of visiting members.

Dr. M. A. Peres, Jun., and Mr. Ernesto Braga, Chairman and Secretary of the Local Committee, for their warm interest and untiring efforts for the success of the meeting.

Messrs. Long, Curtis, Sadler, Bishop, Fox, and Provay, for their timely, efficient and kindly help.

The Governing Bodies of the following institutions, for the privileges granted to members of the Association :—

Gremio Militar,
Gremio Lourenço Marques,
Gremio Nautico (Polana),
English Club,
British Club.
The Golf Club,
The Lawn Tennis Club.

Dr. M. A. Peres briefly acknowledged the vote, stating that it had been not only an honour but also a pleasure to receive the Association.

Vote of Thanks to the President.—Dr. Flint proposed that the meeting accord its heartiest thanks to the President for the able and efficient manner in which he had carried out his onerous duties during the meeting. It had been an honour to the Association and a great pleasure to all the visiting members, and they felt that the great success of the meeting was due to the President for his unfailing courtesy, ever willing help, and his scholarly ability in the Chair. The vote was carried with hearty acclamation.

Dr. Rogers replied that he appreciated the kindness he had received on all hands, and thanked the members for their vote and the hearty manner in which they had passed it.

The meeting then terminated.

REPORT OF THE COUNCIL FOR THE YEAR ENDED 30th JUNE, 1922.

1. Obituary: Your Council has to report, with great regret, the deaths of the following members:—Mr. F. W. Bird, Mr. J. McCracken, Mr. J. J. Dodt, Mr. Alexander Heymann, Dr. J. R. Leech, Dr. R. Milner Smyth.

2. Membership: Since the last Report 152 new members have joined the Association; 6 have died; 43 have resigned; and 76 have been removed from the register by resolution of the Council. The net increase of membership has therefore been 27.

The following comparative table, as from the 1st July in last year, shows the geographical distribution of the membership:—

	1921.	1922.
Transvaal	414	458
Cape Province	279	245
Orange Free State ...	40	46
Natal	98	108
Rhodesia	37	33
Moçambique	8	10
South-West Africa ...	—	—
Abroad	15	20
Unknown	2	—
	893	920

3. The Journal: The publication of Volume XVII, comprising the papers read at Bulawayo, 1920, Meeting, was completed in July, 1921. A double number (Parts 1 and 2) of the *Journal*, Volume XVIII, containing presidential addresses and a selection of papers from each Section read at the Durban Meeting, was issued about the end of February, 1922. Page proofs of the remaining papers have just been received, and a revised list of members is also being printed. The delay, as well as the decision to issue a double number, was due to the change of printers. This delay has also partly resulted from the Editor being situated at such a great distance from the printers. For these reasons it is desirable that the volume should be printed under such conditions as would obviate these disadvantages.

It is unfortunately necessary to draw the attention of authors of papers to the notice on the inside of the cover of the *Journal* that the letterpress of manuscripts submitted for publication should be typewritten, and also that they should be presented in a state fit for publication. The typewritten script needs to be carefully revised by the author himself before presentation for publication. A number of manuscripts submitted last year had to be typed by the Editor from poorly-prepared, hand-written authors'

scripts, and this obviously cannot be continued. The authors in one Section especially gave trouble. Illustrations should also be carefully considered as to their suitability for reproduction, for the Editor has himself had to re-draw numerous authors' sketches at various times. Although the necessity for the frankness of these statements is regretted, yet it is hoped and believed that authors will understand the difficulties in these days of expensive publication, and will do their utmost to reduce the said difficulties to a minimum.

4. THE LIBRARY: It gives great pleasure to the Hon. Librarian to be able to report that the Council has made two grants of £50 each for the purpose of binding books. One of the grants has already been expended and just over one hundred volumes containing many maps, plates and diagrams, have been bound. The binding rendered possible by the second grant is now being undertaken. Some five hundred further volumes still need binding, and the annual increase in the Library is over one hundred volumes, obtained chiefly by exchange.

A few new exchanges have been arranged, and a number of missing parts of volumes have been replaced, for which the thanks of the Association have been tendered.

5. DONATIONS: The thanks of the Association are due to the Hon. the Minister of Education for the renewal of the grant of £250 towards the expenses of the publication of the *Journal.*

Special thanks are also due to the Durban Local Committee and citizens for donations amounting to £625. As a result of the excellent organisation of the 1921 Annual Session, the Association received great financial assistance at a time when it was most required.

6. SOUTH AFRICA MEDAL AND GRANT, 1922: On the recommendation of the South Africa Medal Committee, consisting of Prof. J. Orr (Chairman), Sir J. C. Beattie, Prof. J. Bews, Prof. L. Crawford, Prof. J. E. Duerden, Prof. H. B. Fantham, Dr. B. de St. J. van der Riet, Dr. A. W. Rogers, Sir A. Theiler, Dr. E. Warren, Dr. W. Watkins-Pitchford, and Prof. J. A. Wilkinson, your Council has awarded the South Africa Medal, together with a grant of £50 7s. 10d. to Dr. Illtyd Buller Pole Evans, C.M.G., M.A., D.Sc., F.L.S., Chief of the Division of Botany, Union Department of Agriculture (See p. xxxip). The Secretary of the British Association has been notified of the award.

7. ASSOCIATED SCIENTIFIC AND TECHNICAL SOCIETIES OF SOUTH AFRICA: The relationship of your Association to the Associated Scientific and Technical Societies of South Africa has now been placed on a clear footing. On account of the fact that the membership of your Association is spread throughout South Africa, it was found practically impossible for your Association, as a whole, to exist as a Constituent Society of the Associated Scientific and Technical Societies of South Africa. It was accordingly suggested that the Witwatersrand Local Centre of your Association should become a Constituent Society. This suggestion was accepted by your Council and following this a general meeting of the Witwatersrand members of your Association was held on February 6, 1922. At this meeting the following resolutions were carried unanimously:—

> "That the Witwatersrand Local Centre of the South African Association for the Advancement of Science become a Constituent Society of the Associated Scientific and Technical Societies of South Africa."

and

> "That the members of the Witwatersrand Local Centre agree to the assessment of one guinea per member per annum made by the Controlling Executive of the Associated Scientific and Technical Societies of South Africa."

The monthly Council meetings of the Association and general meetings of the Witwatersrand Local Centre have been held throughout the year in the building of the Associated Societies.

8. British Association for the Advancement of Science : Notification has been received that affiliation with the British Association for the Advancement of Science has been agreed to.

9. The New Council : On the basis of membership provided for in the Constitution of the Association, Section VI (d), the number of members of Council assigned for the representation of each centre during the ensuing twelve months should be distributed as follows :—

Cape Province—	
Cape Peninsula	5
East London and Port Elizabeth	1
Kimberley	1
Kingwilliamstown	1
Grahamstown and district	1
Stellenbosch	2
Outside	1
Natal—	
Maritzburg	2
Durban	2
Outside	1
Orange Free State—	
Bloemfontein	2
Transvaal—	
Witwatersrand	17
Pretoria	4
Potchefstroom } Transvaal Outside }	1
Rhodesia	2
Moçambique	1
	44

REPORT OF THE HONORARY GENERAL TREASURER FOR THE YEAR ENDING MAY 31st, 1922.

The presentation of the balance sheet and statement of revenue and expenditure for the twelve months ending May 31st, 1922, is a much more pleasant task than has been the case with my predecessors in this office of recent years, because this year we are able to show a substantial balance.

The main considerations which have helped towards this satisfactory position are :—

(1) Increased revenue from membership fees.
(2) Increased donations amounting approximately to £600.
(3) Reduced expenditure on printing the *Journal*.

As members are aware, from the 1st July, 1921, the membership fee was increased to £1 10s. 0d. and the revenue from this source for the year is almost exactly 50 per cent. more than that obtained last year. This increase has been obtained without any sacrifice of membership.

The unexpected windfalls to which Mr. Foote referred in his report last year came at a most opportune time, and relieved the Council of considerable financial anxiety.

A considerable saving is also shown in the cost of printing the *Journal*, and it was clearly the duty of the Council to accept the most reasonable tender received. Delay in publication of the *Journal* is more than compensated for by the considerable reduction in expenditure shown under this head. Under these circumstances, the delay in issuing the *Journal* must be favourably regarded by members, for no Council can reasonably authorise an expenditure on the *Journal* which is greater than the sum received in membership subscriptions when tenders more in accord with the Association's income are received.

The principle of praying for fortuitous donations to balance the revenue and expenditure of the Association is not sound.

We are, therefore, able, after paying over to the Endowment Fund the sum of £131 in respect of life membership fees which had to be withheld for two years, and allowing the sum of £350 for printing parts 3 and 4 of the *Journal*, together with a list of members, to show an excess of revenue over expenditure of £807 0s. 10d.

This sum after deduction of the deficits shown on the previous two years amounting to £487 2s. 7d. leaves a balance of £319 17s. 11d.

The Association still continues to carry a large number of members who are in arrear with their subscriptions, and for whom it is necessary to make provision to supply copies of the *Journal* in case they should put themselves in good standing with the Association.

Your consideration will be invited to an addition to the Constitution giving power to the Council definitely to strike off the roll the names of such members as are in arrear with their subscriptions for two years, after due notification.

Owing to the satisfactory financial position it has been possible to make a start in overtaking the arrears in the binding of volumes in the Library, and a further sum of £50 has already been appropriated towards this object for next year.

JAS. GRAY.

Honorary General Treasurer.

3rd July, 1922.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
BALANCE SHEET AS AT 31st MAY, 1922.

LIABILITIES.

Sundry Creditors—		
Library Deposits	£3 0 0	
A. W. Vorenberg & Company ...	1 17 6	
Hortors, Ltd.	0 6 6	
Remington Agency	0 3 6	
Subscriptions paid in advance ...	7 10 0	
Provision for estimated cost of printing JOURNAL and List of Members	350 0 0	
S.A. Medal Award	50 7 10	
		£413 5 4
Endowment Fund—		
Amount in hands of Trustees ...	1,704 0 0	
Add—Liability for Life Members' Subscriptions not yet paid over to Trustees	20 0 0	
		1,724 0 0
South Africa Medal Fund		1,445 13 8
Revenue and Expenditure Account—		
Excess of Revenue over Expenditure for year to 31st May, 1922 ...	807 0 10	
Less—Balance as at 31st May, 1921	487 2 11	
		319 17 11
		£3,902 16 11

ASSETS.

Cash—		
At Bank	£253 2 0	
On hand	2 19 9	
With National Bank of South Africa, Ltd.—Savings Bank Account ...	400 0 0	
		£656 1 9
Medals on hand		6 7 5
Furniture		23 6 9
Trustees—Endowment Fund—		
Balance at 31st May, 1921	1,579 15 3	
Less—Interest since paid	6 15 3	
	1,573 0 0	
Add—Amount of Life Members' Subscriptions for 1920 and 1921 paid over	131 0 0	
	1,704 0 0	
Add—Interest due on Cape of Good Hope Savings Bank Account ...	9 3 9	
		1,713 3 9
Trustees—South Africa Medal Fund—		
Amount of Fund	1,445 13 8	
Add—Interest due	58 3 7	
		1,503 17 3
		£3,902 16 11

We have examined the books and vouchers of the South African Association for the Advancement of Science for the year ended 31st May, 1922, and certify that in our opinion the above Balance Sheet correctly sets forth the position of the affairs of the Association at the 31st May, 1922, according to the best of our information and the explanations given us and as shown by the books.

Johannesburg,
19th June, 1922.

ALEX. AIKEN & CARTER, *Auditors.*

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

REVENUE AND EXPENDITURE ACCOUNT FOR THE TWELVE MONTHS ENDED 31ST MAY, 1922.

Dr.

To Assistant General Secretary's Salary ...			£145 0 0
,, Rent			30 0 0
,, JOURNAL Expenses		£397 0 8	
Add—Provision for cost of printing remainder of 1921-22 proceedings and list of Members		350 0 0	
		747 0 8	
Less—Sales and reprints	£23 19 4		
Donation — Union Department of Education ...	250 0 0		
		273 19 4	
			473 1 4
,, Printing and Stationery			26 2 4
,, Stamps and Telegrams			11 0 7
,, Sundry General Expenses			13 1 9
,, Grant under Rule IX.			2 2 0
,, Expenses Annual Meeting			42 14 8
,, Depreciation of Furniture			2 11 10
,, Library Binding Account			51 1 0
,, Balance, being excess of Revenue over Expenditure			807 0 10
			£1,603 16 4

Cr.

By Annual Subscriptions	£782 0 0
,, Arrears Subscriptions	95 10 0
,, Associates Subscriptions	17 0 0
,, Interest on Endowment Funds collected	83 13 9
,, Donations	625 12 7
	£1,603 16 4

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

ENDOWMENT FUND ACCOUNT FOR THE YEAR ENDED 31ST MAY, 1922.

Dr.			Cr.		
To Interest transferred to General Account	£83 13 9	By Balance, 31st May, 1921		£1,704 0 0
,, Balance, 31st May, 1922	1,724 0 0	,, Life Membership Subscriptions ...		20 0 0
		,, Interest on Investments	£74 10 0	
		,, Interest on Cape of Good Hope Savings Bank Account	9 3 9	
				83 13 9
	£1,807 13 9			£1,807 13 9

SOUTH AFRICA MEDAL FUND ACCOUNT FOR THE YEAR ENDED 31ST MAY, 1922.

To Award to Dr. I. B. Pole Evans, C.M.G.	£50 7 10	By Balance at 31st May, 1921	£1,445 13 8
,, Expenses in connection with Award ...	7 15 9	,, Interest received	58 3 7
,, Balance, 31st May, 1922	1,445 13 8		
	£1,503 17 3		£1,503 17 3

FIFTEENTH AWARD OF THE SOUTH AFRICA MEDAL AND GRANT.

(Fund raised by Members of the British Association in Commemoration of their visit to South Africa in 1905.)

After the conclusion of the Presidential Address, in the large hall of the Railway Headquarters, Lourenço Marques, on Monday, July 10, 1922, the President, Dr. A. W. Rogers, F.R.S., presented the South Africa Medal, together with a grant of £50, to Dr. Illtyd Buller Pole Evans, C.M.G., M.A., D.Sc., F.L.S., Chief of the Division of Botany and Plant Pathology, and Director of the Botanical Survey, Union of South Africa.

In making the presentation, the President said :—

Illtyd Buller Pole Evans, after a distinguished student career at the University College of South Wales, Cardiff, graduated B.Sc. in 1903. He thence proceeded to Cambridge, specialising in the study of Plant Pathology and Mycology under the late Professor Marshall Ward, and taking his research degree in 1905.

In July, 1905, he accepted an appointment in the Division of Botany of the Transvaal Agricultural Department, and in 1912 the value of his services was specially recognised by the creation of a Division of Plant Pathology and Mycology, under his care. In 1913 the Divisions of Botany and Plant Pathology were amalgamated with Dr. Pole Evans as Chief—an arrangement which holds to this day.

The year 1918 brought him an honour from his old University in the degree of D.Sc., and an additional responsibility in the Directorship of the Botanical Survey of South Africa.

He had for many years taken a prominent part in associations devoted to the advancement of his subject, being a Fellow of the Linnean Society of London since 1907, Fellow of the Royal Society of South Africa, President of the Transvaal Biological Society in 1911, and Council member of the South African Biological Society since its formation. In 1919 the Biological Society honoured him in his private capacity by the award of the Scott Memorial Medal for individual researches; and in 1920 his public interest in science was recognised by the South African Association for the Advancement of Science in electing him President.

The conferring of a C.M.G. by His Majesty, in the New Year Honours List of 1921, is a still more public recognition of that reputation which he has long enjoyed amongst his scientific confrères.

Despite his manifold public and administrative responsibilities, his published scientific work has suffered no pause in continuity. As editor of "Bothalia," and of the "Flowering Plants of South Africa," as conjoint author in collaboration with the growing staff of his Division, and as sole author of individual contributions, his name remains prominent in the main current of scientific literature. Most of his work naturally takes a practical economic form, but the purer aspects of his science are not thereby overshadowed. A glance at the following list of papers will illustrate his ceaseless scientific activity and the diversity of his range.

Scientific Papers.

1. "Infection Phenomena in Various *Uredineæ*." Rept. British Assoc. for Advancement of Science, S. Africa, 1905, pp. 595-596.
2. "Note on *Fusicladium* affecting Apples and Pears in Cape Colony." Trans. Agric. Journ. IV, 1906, pp. 827-829.
3. "The Cereal Rusts." Ann. Rep. Trans. Dept. Agric. for 1906-7, V. 1907, pp. 163-5.
4. "Coffee Rusts" (*Hemileia vastatrix* Berk and Br.). Ann. Rep. Trans. Dept. Agric. 1906-7, V, pp. 165-6.

5. "The Cereal Rusts 1. The Development of their Uredo mycelia." Annals of Bot., XXI, 1907, pp. 441-446.
6. "The South African Locust Fungus, *Empusa grylli*, Eres." Trans. Agric. Journ., V, 1907, pp. 933-939.
7. "On the Systematic Position of *Aecidium elegans*, Diet." Rept. S. African Ass. Adv. Sc., 1908, pp. 252-253.
8. "Bitter Pit of the Apple." Transvaal Dept. of Agric., Techn. Bull. No. 1, 1909.
9. "On the Structure and Life-History of *Diplodia Natalensis*, n. sp., the Cause of the 'Black Rot' of Natal Citrus Fruit." Trans. Dept. of Agric. Sc. Bulletin, 4, 1910.
10. "South African Cereal Rusts, with Observations on the Problem of Breeding Rust-Resistant Wheats." Journ. of Agric. Science, IV, pt. 1, 1911, pp. 95-104.
11. "A Fungus Disease of Bagworms in Natal." Annals Mycologici, X, No. 3, 1912, pp. 281-284.
12. "Three Fungi collected on the Percy Sladen Memorial Expedition of 1910-11 and 1912-13." Annals of Bolus Herbarium, I, 1915, p. 115.
13. "Note on a Variety of *Kalchbrennera Tuckii* (Kalch and MacOwan) Berk. from Grahamstown and Kentani Districts." Records of the Albany Museum, III, 1915, p. 157.
14. "The South African Rust Fungi, I. The Species of *Puccinia* on Compositæ." Trans. Roy. Soc. S. Afr., V, 1916, pp. 637-646.
15. "Descriptions of Some New Aloes from the Transvaal, Pt. I." Trans. Roy. Soc. S. Africa, V, 1916, pp. 25-35.
16. "A New Aloe from Swaziland." Trans. Roy. Soc. S. Africa, V, 1916, pp. 603-4.
17. "Descriptions of Some New Aloes from the Transvaal. Pt. II." Trans. Roy. Soc. S. Africa, V, 1917, pp. 703-711.
18. "A Sketch of the Rise, Growth, and Development of Mycology in South Africa": being Presidential Address to Section C, S. African Assoc. Adv. of Science, 1916. S. African Journ. of Science, 1916, pp. 1-20.
19. "A New Smut on *Sorghum helepense* Nees." S. African Journ. of Science, June, 1916.
20. "South African Fibre Plants, I., Ambari or Deccan Hemp, *Hibiscus cannabinus* L." S. African Journ. of Industries, I, 1917, pp. 198-208.
21. "The Plant Geography of South Africa." Official Year-book of the Union, No. 1, 1917.
22. "Novitates Africanæ." Annals of Bolus Herbarium, II, 1917, pp. 109-111.
23. "On the Genera *Diplocystis* and *Broomeia*." With A. M. Bottomley. Trans. Roy. Soc. S. Afr., VII, Part III, 1919.
24. "Note on the genus *Terfezia*, a Truffle from the Kalahari." Trans. Roy. Soc. S. Afr., VII, Part II, 1918.
25. "Teff Rust." Kew Bulletin, 1918.
26. "The Veld: Its Resources and Dangers." Presidential Address to the South African Association for the Advancement of Science, 1920. S. African Journ. of Science, XVII, pp. 1-34, with 28 plates.
27. "The Plant Geography of South Africa." Official Year Book, No. 5, 1922.
28. "The Vegetation of South Africa." (In press.)
29. "The Main Botanical Regions of South Africa." Botanical Survey of South Africa. Memoir No. 4, 1922.
30. "Report on Cold Storage Conditions for Export Fruit." Dept. Agric. Bulletin No. 2, 1920.
31. "Further Investigations into the Cause of Waste in Export Fruit." Dept. Agric., Bulletin No. 1, 1921.
31. "Further Investigations into the Cause of Waste in Export Citrus Fruit from South Africa." With Thomson, Putterill and Hobson. Dept. of Agric., Bulletin No. 1, 1922.

General Articles.

32. "Notes on Diseases of Plants." Trans. Agric. Journ., IV, 1905, pp. 148-149.
33. "Smut in Wheat, Barley and Oats, and How to Prevent it." Trans. Agric. Journ., IV, 1906, pp. 389-396.
34. "The Citrus Fruit Rot, caused by the Blue Mould, *Penicillium digitatum* (Fr.) Sacc." Ann. Rept. Trans. Dept. Agric., 1906-1907, VI., 1908, pp. 60-62.
35. "The New York Apple Tree Canker, or Black Rot Fungus in South Africa." Trans. Dept. Agric., Bull. No. 25.
36. "Potato Rot." Trans. Dept. Agric., Bull. No. 30.
37. "Anthracnose or Zwart Roest of the Grape." Trans. Dept. Agric., Bull. No. 15.
38. "Peach Leaf Curl." Trans. Dept. Agric., Bull. No. 10.
39. "Potato Scab." Dept. of Agric., Union of South Africa, Bull. No. 19.
40. "The Powdery Mildew of the Grapes." Dept. of Agric., Union of South Africa, Bulletin No. 9.
41. "The Mildew of the Grape Vine." Trans. Agric. Journ., VII, 1909. Pp. 213-217.
42. "A Note on the European Apple Tree Canker." Trans. Agric. Journ., VII, 1909, p. 217.
43. "Peach Freckle, or Black Spot." Dept. of Agric., Union of S. Africa, Bull. No. 57.
44. "The Downy Mildew of the Grape." Dept. of Agric., Union of S. Africa, Bull. No. 13.
45. "Black Scab or Warty Disease of the Potato." Dept. of Agric., Union of S. Africa, Bull. No. 3.
46. "Corky Scab of the Potato." Trans. Agric. Journ., VIII, 1910, pp. 462-3.
47. "A New Disease of Citrus Fruit." Trans. Agric. Journ., VIII, 1910, pp. 463-5.
48. "A Fungus Disease of Bagworms." Dept. of Agric., Union of S. Africa, Bull. No. 35.
49. "Dik-Voet, Club-Root, or Finger and Toe in S. Africa." Dept. of Agric., Union of S. Africa, Bull. No. 39.
50. "Maize Smut or Brand." Dept. of Agric., Union of S. Africa, Bull. No. 56.
51. "Smut in Kaffir-corn." Dept. of Agric., Union of S. Africa, Bull. No. 45.
52. "Plant Disease in South Africa." Dept. of Agric., Union of S. Africa, Bull. No. 45.
53. "Notes on the South African Flora." South African Railways and Harbours Magazine.
54. "The Aloes at Union Buildings, Pretoria." South African Gardening, July, 1917.

PREVIOUS RECIPIENTS OF THE SOUTH AFRICA MEDAL.

1908. *Grahamstown.*—Arnold Theiler, C.M.G., V.M.D., Bacteriologist to the Transvaal Government, Pretoria.
1909. *Bloemfontein.*—Harry Bolus, D.Sc., F.L.S., of Sherwood, Kenilworth, Cape Division.
1910. *Capetown.*—John Carruthers Beattie, D.Sc., F.R.S.E., Professor of Physics, South African College, Capetown.
1911. *Bulawayo.*—Louis Péringuey, D.Sc., F.E.S., F.Z.S., Director of the South African Museum, Capetown.
1912. *Port Elizabeth.*—Alexander William Roberts, D.Sc., F.R.A.S., F.R.S.E., of Lovedale Observatory, Cape Province.
1913. *Lourenço Marques.*—Arthur William Rogers, M.A., Sc.D., F.G.S., Assistant Director of the Union Geological Survey, Capetown.
1914. *Kimberley.*—Rudolph Marloth, M.A., Ph.D., Capetown.

1915. *Pretoria.*—Charles Pugsley Lounsbury, B.Sc., F.E.S., Chief of the Division of Entomology, Union Department of Agriculture, Pretoria.

1916. *Maritzburg.*—Thomas Robertson Sim, F.L.S., F.R.H.S., formerly Conservator of Forests for Natal.

1917. *Stellenbosch.*—John Dow Fisher Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S., Professor of Zoology, South African College, Capetown.

1918. *Johannesburg.*—Robert Thorburn Ayton Innes, F.R.S.E., F.R.A.S., Union Astronomer, Johannesburg.

1919. *Kingwilliamstown.*—James Moir, M.A., D.Sc., F.I.C., Government Mining Chemist, Johannesburg.

1920. *Bulawayo.*—Ernest Warren, D.Sc., Director of the Natal Museum and Professor of Zoology in Natal University College, Pietermaritzburg.

1921. *Durban.*—Sir Frederick Spencer Lister, Kt., M.R.C.S., L.R.C.P., Research Bacteriologist to the South African Institute for Medical Research, Johannesburg.

ASSOCIATION LIBRARY.

The following publications are filed at the Association's Room in the Public Library, Johannesburg:—

General Science.

Royal Society of Edinburgh: Proceedings.

Royal Society of South Africa: Transactions.

Royal Society of South Australia: Memoirs.

Royal Society of South Australia: Transactions.

Royal Society of Victoria: Proceedings.

Royal Society of Canada: Proceedings and Transactions.

Royal Society of Tasmania: Papers and Proceedings.

Royal Society of Queensland: Proceedings.

Royal Dublin Society: Scientific Proceedings.

Royal Institution of Great Britain: Proceedings.

Royal Philosophical Society of Glasgow: Proceedings.

Royal Society of Arts: Journal.

Michigan Academy of Science: Reports.

Chicago Academy of Sciences:
Bulletins.
Special Publications.

Reale Academia dei Lincei, Rome: Atti.

Kungl. Svenska Vetenskapsakademien:
Handlingar.
Arsbok.

Koninklijke Akademie van Wetenschappen, Amsterdam:
Proceedings of the Section of Sciences.
Verhandelingen.

Real Academia de Ciencias de Madrid: Revista.

British Association for the Advancement of Science: Reports.

Australasian Association for the Advancement of Science: Reports.

American Association for the Advancement of Science: Proceedings.

Indian Association for the Cultivation of Science:
- Proceedings.
- Reports.
- Bulletins.

Società Italiàna por il progresso della Scienze: Atti.

Association Française pour l'avancement des Sciences: Conférences.

Cambridge Philosophical Society:
- Transactions.
- Proceedings.

Manchester Literary and Philosophical Society: Memoirs and Proceedings.

American Philosophical Society: Proceedings.

University of California:
- Bulletins.
- Memoirs.

University of Virginia: Philosophical Society Bulletins.

Tôhoku Imperial University: Science Reports.

New York Academy of Sciences: Annals.

American Academy of Arts and Sciences: Transactions.

Connecticut Academy of Arts and Sciences: Proceedings.

Meddelanden fran K. Vetenskapsakademien Nobelinstitut.

California Academy of Sciences: Proceedings.

Academy of Science of St. Louis: Transactions.

Academy of Natural Sciences of Philadelphia: Proceedings.

American Journal of Science.

Ohio Journal of Science.

Nova Scotian Institute of Science: Proceedings and Transactions.

Revue Générale des Sciences.

Archives Néerlandaises des sciences exactes et naturelles.

Annaes scientificos da Academia polytechnica do Porto.

Rhodesia Scientific Association:
- Annual Reports.
- Proceedings.

Société de physique et d'histoire naturelle de Genève:
- Memoirs.
- Comptes rendus.

Det Kongelige Norske Videnskapers Selskaps Skrifter.

Kongelige Danske Videnskabernes Selskab: Oversigt.

Vierteljahrsschrift der naturforschenden Gesellschaft, Zurich.

Imperial Institute: Bulletins.

New Zealand Institute: Transactions and Proceedings.

Annual Report of the Smithsonian Institution (United States National Museum).

South African Museum:
- Annals.
- Annual Reports.

Transvaal Museum: Annals.

Natal Museum: Annals.

Queensland Museum:
- Annals.
- Memoirs.

Field Museum of Natural History Publications.

University of Pennsylvania Museum Journal.

Public Museums of Milwaukee : Bulletins.

Albany Museum :
    Annual Reports.
    Records.

Knowledge.

Science.

Franklin Institute : Journal.

University of Minnesota : Current Problems.

Chemistry, Metallurgy and Geology.

Chemical, Metallurgical and Mining Society of South Africa : Journal.

Kungl. Svenska Vetenskapsakademien : Arkiv för Kemi, Mineralogi, och Geologi.

Geological Society of South Africa : Transactions.

Geological Society of Tokyo : Journal.

Geological Survey of New South Wales : Reports.
    Memoirs.
    Mineral Resources.

Geological Institution of the University of Upsala : Bulletins.

Geological Society, London : Abstracts of Proceedings.

Bulletins of the Wyoming State Geologist.

United States Geological Survey :
    Annual.
    Mineral Resources.
    Bulletins.
    Monographs.
    Professional Papers.

Florida State Geological Survey Annual Reports.

Servico geologico e mineralogico do Brasil : Monographias.

Union of South Africa Mines Department : Annual Reports.

Canada Department of Mines :
    Museum Bulletins.
    Memoirs of the Geological Survey.
    Reports.

New South Wales Department of Mines : Annual Reports.

The Mineralogical Magazine.

Egyptian Ministry of Finance : Geological Reports.

Geological Survey of Western Australia :
    Annual Progress Reports.
    Bulletins.

Journal of Industrial and Engineering Chemistry.

Journal of Chemical Technology.

The Chemical News.

University of Minnesota : Studies in Chemistry.

Journal of the South African Chemical Institute ; and Proceedings.

Meteorology.

Royal Meteorological Society : Quarterly Journal.

Mount Weather Observatory : Bulletins.

Observatorio Campos Rodrigues :
    Relatorio.
    Resumo mensal.

Egyptian Ministry of Finance : Meteorological Reports.

Agriculture.

Regia Scuola superiore agricoltura di Portici: Annali.

International Institute of Agriculture: Rome.
International Crop Report and Agricultural Statistics.
International Review of the Science and Practice of Agriculture.
Documentary Leaflets.
Statistical Notes on the Cereals.

Massachusetts Agricultural Experiment Station:
Annual Reports.
Bulletins.

Maine Agricultural Experiment Station: Annual Reports.

Agricultural Gazette of New South Wales.

Department of Agriculture, New South Wales: Science Buildings.

United States Department of Agriculture:
Experiment Station Record.
Year Book.

New York State College of Agriculture and Experiment Station:
Annual Reports.

Journal of Agricultural Research.

Rhodesia Agricultural Journal.

Revista de Agricultura, Comercio y Trabajo, Cuba.

Bulletin Agricole de l'Algerie-Tunisie-Maroc.

Station agronomique de la Guadeloupe: Bulletin.

Union of South Africa Agricultural Journal.

Biology and Physiology.

Bulletin de la Société Imperiale des naturalistes de Moscou.

Kungl. Svenska Vetenskapsakademien:
Arkiv för Botanik.
Arkiv för Zoologi.

Journal of the Linnean Society, Botany.

Bulletin of the Wisconsin Natural History Society.

The Medical Journal of South Africa.

University of California: Publications in Botany.

Linnean Society of New South Wales: Proceedings.

Missouri Botanical Garden:
Annual Reports.
Annals.

Bolus Herbarium: Annals.

Smithsonian Institution (United States National Museum): Contributions from the United States National Herbarium.

Royal Botanic Gardens, Kew: Bulletins.

Union of South Africa: Reports of the Director of Veterinary Research.

University of Michigan, Museum of Zoology:
Miscellaneous Publications.
Occasional Papers.

Lloyd Library:
Bibliographical contributions.
Mycological Notes.

South African Biological Society: Bulletins.

Memorias do Instituto Oswaldo Cruz, Rio de Janeiro.

Entomology.

Bulletin of Entomological Research.

Review of Applied Entomology.

Bacteriology.

Abstracts of Bacteriology.

Astronomy, Mathematics and Physics.

Royal Astronomical Society:
- Memoirs.
- Monthly Notices.

Journal of the Royal Astronomical Society of Canada.

Harvard College Astronomical Observatory:
- Circulars.
- Annals.
- Annual Reports.

Leyden Sterrenwacht: Annalen.

Union Observatory Circulars.

Cape Observatory.
- Annals.
- Reports.
- Cape Astrographic Zones.

Observatoire Royal de Belgique; annuaire astronomique.

Khedival Observatory, Helwan, Egypt: Bulletins.

Kodiakanal and Madras Observatories: Annual Reports.

British Astronomical Association:
- Journal.
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POST-CRETACEOUS CLIMATES OF SOUTH AFRICA.

BY

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Presidential Address delivered July 10, 1922.

For the second time this Association meets in the pleasant surroundings of Lourenço Marques by the generous hospitality of our Portuguese friends, and we owe a debt of gratitude to Mr. Seruya, the former Vice-Consul in the Union, for initiating the idea of the invitation. It must always be a specially interesting event to us to meet in this territory belonging to the countrymen of those pioneers in modern African exploration, Prince Henry the Navigator, Bartholomew Diaz and Vasco da Gama.

I must express my sense of the honour you conferred upon me by electing me your President. I have been a member of the Association since 1902, but circumstances have prevented me from attending more than two of the Annual Meetings. Having taken so small a part in your proceedings, though the Journal is well known to me, I am perhaps the better able to record my opinion of the great value of the Association in encouraging those who have something they wish to put before a wider audience than is to be found at a meeting of one of the more specialised societies. The Association has rendered good service in this respect for the past 20 years, and, judging from the support it receives throughout South Africa, it promises to have a future of steadily increasing usefulness. Another important function is that of giving workers in different subjects and in different parts of the country opportunities of becoming personally known to each other, and of meeting many who are not actually engaged in scientific investigation, but who are interested in it and who are often able to throw light on some aspect of special studies which may be most useful to the specialist. A third object, the most important of all, which we often wish were not so difficult of attainment, is the spread of scientific method in various relations of life. This, after all, is the thing commonly called looking facts in the face without being led astray by our desires or conventions.

Past Climates.

Ralph Waldo Emerson was not a scientific man in the narrow sense of the word, but when he wrote " the best part of truth is certainly that which hovers in gleams and suggestions unpossessed before man. His recorded knowledge is dead and cold. But

this chorus of thoughts and hopes, these dawning truths, like great stars just lifting themselves into his horizon, they are his future "—he described very well an impulse on all inquirers into the physical world about them. Whether he was right in calling the half-perceived the best part of truth must be judged by its effect in compelling investigation, but Emerson's maxim will serve me as an apology for choosing climates of former times as the subject of my address; for there are many uncertainties inherent in the methods of the inquiry. The evidence has to be got from many sources, any one of which alone may not take us far.

Past climates are of interest from several points of view; we can attempt to reconstitute in mind the conditions under which the former inhabitants of a country lived; to understand how the present surface of a country became shaped as we find it; or we may discover whether change in climate is continuous in one direction for a period comparable with one of the recognised subdivisions of geological time, such as the Pleistocene, and whether we are living in such a period.

That the climate of what is now South Africa has changed during geological time is as certain as such things can be, for the evidence of the existence of land-ice between the Transvaal and Natal on the one hand and the Tanqua Karroo on the other during the Carboniferous period has been accumulating ever since Dr. Sutherland published his recognition of it in Natal in 1868,[1] and hardly a year goes by without fresh facts being discovered which support the theory. In this instance the evidence consists of the preserved effects of the movement of ice over hard rock, and there is an immense body of corroborative evidence in the tillite, or hardened boulder-clay, remaining on that rock and distributed over the country to the south for more than a hundred miles. The evidence is entirely independent of fossil plants and animals, for the characters of the rocks themselves are the only source of information. It was only in very much later times that animals and plants bore such close resemblance to those living to-day that their remains afford satisfactory evidence of climatic conditions based on a comparison of their distribution with that of living forms. This instance alone is sufficiently striking to justify inquiry into changes of lesser range, and it is advisable before going further to consider briefly the various kinds of evidence to be expected and searched for in order that we may discuss the relevant facts from South Africa.

What we call climate is the result of many factors, and a meteorologist could tell us just what the climate was at any particular place and time if he were given the necessary information about the Sun's radiation, the rotation of the Earth, the distribution of land and water on it and of the air above it at the time in question, but my purpose is only to discuss the evidence

[1] The numbers refer to notes, which are collected together at the end of this address.

for the kind of climate, not to attempt deductions from any assumed physical changes, such, for instance, as a different distribution of land and water. Such deductions may well be profitable in the future when there is a more secure foundation to build on; when, for instance, at least the main features of the hypothesis of crustal creep put forward by Taylor and Wegener[2] shall have been settled, according to which the existing continents have changed their positions in latitude and longitude very considerably during past times. It is obvious that should the hypothesis be found valid it will bear intimately upon climate, and it was used by Dr. du Toit at our last Annual Meeting[3] to explain the hitherto insoluble difficulty of understanding the Carboniferous glaciation in present-day temperate latitudes of the southern hemisphere. Revolutionary as the hypothesis may appear, it is now assured of serious attention, and it is on geological evidence that it will stand or fall. In our time we have seen conclusions about the age of the Earth drawn from geological and biological arguments receive support from the successors of astronomers and physicists who, reasoning fifty years ago from too limited knowledge, said that evolutionists' demands upon time were much too great; so whatever may be the physical difficulties of the new hypothesis, it will be judged by such methods as close comparison of the rocks and structure of eastern South America and western Africa.

The evidence upon which we have to depend for recognising kinds of former climate falls into four groups; the first is drawn from the characters of the rocks formed during the period concerned; the second relates to the shapes of the land surface resulting from the long duration of more or less constant climatic conditions; the third concerns the distribution of animals and plants; and the fourth is historical, the records, archæological, traditional and written, of the period since man occupied the country. It is obvious that these four groups are very dissimilar, and, in general, each can be drawn upon for information about certain periods only.

Lithological Evidence.

The lithological evidence is by far the most important for all but comparatively recent times, certainly for the whole of pre-Tertiary time. The character of sediments formed by the accumulating materials worn from the land depends upon the kind of rock forming the land and the climate prevailing there. Though the Earth's crust is made up of a large number of different rocks, their mineral constituents are few; the felspars, quartz, mica, and a few other dark silicates, are by far the most important, and they, together with water, oxygen, and carbon dioxide obtained from the air in the course of weathering, form 99 per cent. of the sedimentary rocks. The grains and much of the cement of the sediments ultimately come from igneous rocks, which, in spite of their name, have nothing to do with fire but are mixtures of minerals which crystallised out from

solutions. The solid rocks of the land are broken up by changes of temperature, by friction of one piece against another when moved by gravity, wind or water, and by animals and plants. The rounding-off of the edges of the grains as derived from the breaking up of the parent rock is much more complete when done in the air than in water, and the process is carried on in smaller particles; the limit of size of a rounded water-worn grain of quartz has been found by experiment[4] to be about 0·1 mm., but much smaller particles have their edges worn off when blown about with other grains of sand. With the very important exception of quartz, almost all the common rock-forming minerals are chemically altered near the surface of the ground by water containing in solution various substances derived from the air and from organisms; and this water dissolves an appreciable quantity of them, even of quartz. It is in the character and extent of this alteration that the influence of climate makes itself felt, chiefly through its control of life[5]. A very dry climate is unfavourable to the existence of animals and plants, and the mineral grains in such a climate are mainly the result of the physical disintegration of the rock; the felspars, for instance, the most important of the primary rock-forming minerals, retain in such a climate the optical characters peculiar to them and can be recognised in the smallest particles resolvable by the microscope. So when we find beds of sediment in which there is much felspar in small grains, there is a presumption that the land which furnished the grains had a dry climate. There is probably no country so dry that the silicates are not partly decomposed, but owing to the amount of water being insufficient to gather into streams or to leak away through joints, much of it evaporates at or near the surface and substances held in solution are deposited amongst the particles forming the soil. Carbonates of lime and magnesia, hydrated oxides of iron, silica and sulphate of lime and chloride of sodium are the chief substances deposited in this way in dry climates.

Moist, warm countries have deep soils made of clay and quartz sand; the abundant vegetation in such countries, from bacteria, low in the scale of life but probably the most important of all organisms in bringing about changes in minerals, to the forest tree, co-operates with animal life in destroying the original characters of rocks and minerals, leaving behind clays, silica and soluble salts. A product confined to tropical climates, and apparently to regions where there is a marked contrast between wet and dry seasons, is laterite, a residual clay rich in hydroxides of alumina and iron; somewhat similar rocks without free alumina are formed in temperate climates, both at and below the surface.

There is no sharp division between arid and humid climates, and only the extreme types, arid on the one hand, and wet and hot on the other, impress readily recognisable characters upon the contemporaneously formed sediments.

The effect of a very cold climate upon its sediments resembles that of arid conditions in that it also restrains vegetation, so that

lands under glacial control furnish a large part of their silicates in a fresh state to the sediments accumulating on and around them. These sediments, however, often contain fragments of rock showing characteristic scratches, and they may present other features which enable their recognition; angular grains are abundant, there may be little sorting of large and small fragments, and the iron compounds are not wholly oxidised to the ferric state which gives a red colour to sands of the desert as well as to much of the soil of the tropics.

Evidence from Topography.

The shape of a land surface is the result of all the agents of denudation which have affected it since it first became subject to their influence. The initial shape of the surface can to some extent be pictured in imagination with the help of a knowledge of the structure of the rocks forming the area in question; thus the initial shape of our Karroo region, as indicated by its structure, was one of low relief, without marked ridges, and the areas of rising ground on it were due to piles of lavas and tuffs; while the country to the south, where the Cape ranges now are, almost certainly had distinct east and west ridges from its earliest days, though these ridges became more and more pronounced as the harder rocks in them became exposed. Though the structure of a region has an important influence on the shapes subsequently assumed down to a very late stage in the evolution of the surface, the details vary with the agents at work. The final stage is a low slope from the watershed to the sea, and it is rarely attained in fact. The nearly flat surface, called a peneplain, can be imagined to extend over a continent, but the peneplains of our acquaintance are not so large; they are extending upstream towards the watersheds, but we find hills rising from and around them. To become a peneplain by the work of rain, wind and rivers is the ultimate fate of the land, and it would be a plain of erosion; but it is doubtful whether such a peneplain would result under arid conditions during any one climatic period of which a geologist could admit the duration.[6] An arid peneplain, such as the Kalahari and Bushmanland, is probably a composite thing, made partly of flat-cut rock and partly of filled-in valleys. The isolated hills rising from a peneplain in an arid climate usually have a peculiar form; they are made of hard rocks. They have straight slopes, and their base is very sharply defined by the sudden change of slope where they rise from the plain. Hills of this type have been called Inselberge, island-mountains, a good descriptive term.[7] Many of them have no rock fragments lying more than a few yards from the lowest outcrops owing to the cover of sand on the plain, and this sand buries the base of the hill. Passarge[8] describes great plains in the Bechuanaland Protectorate cut nearly flat in hard rock, and he attributed the erosion to wind alone.

The depressions called pans or vleys[9] in South Africa are characteristic of dry countries, and their origin has been much

discussed. Their width ranges from a few yards to a few miles. They have flat floors and they generally have no outlet.[10] There can be little doubt that wind alone can start their formation in flat country, and it is aided by increasing brakness of the ground in a depression, for growth of protective vegetation is thereby hindered and eventually prohibited. The important part played by animals in the formation of certain kinds of pan[11] has been abundantly illustrated by Passarge. In a humid climate pans of erosion cannot form, and were a pan-veld to become well supplied with water the pans would eventually either be filled up by material washed into them or, in the event of their being filled to overflowing with water, they would eventually be drained by streams cutting back into them. The presence of horizontal beds is certainly a favourable condition for their formation.

The forms produced by erosion and deposition under glacial conditions need not detain us long; they are characteristic both in mountainous country and on plains, but they have not been produced on the post-Cretaceous surface of South Africa. Though it is occasionally stated that evidence of former glaciers is to be seen in the higher parts of the country, no confirmation has been obtained in the course of the Geological Survey, and I am permitted to say that during their recent visit to Mont aux Sources Professor Daly and Dr. Wright found no evidence of that kind.

Evidence from Fossils.

The palæontological evidences of climate are difficult to interpret; plants afford more information than animals because the preservation of their tissues allows botanists to draw conclusions about transpiration, which may throw light on climate; but well-preserved plants are rare. The value of a comparison of the distribution of fossil species and their living relatives decreases as we go back in time, but a large part of the information about the climate of late Tertiary and Pleistocene times in Europe depends upon evidence of this kind, and it has been skilfully combined with that from the work of ice. Evidence of this kind is open to suspicion; from the bones of the mammoth probably no anatomist would suspect that it differed greatly in its habitat from its living relatives in tropical and temperate regions, but the frozen carcases in Siberia prove that it lived in a cold climate and was specially protected against the effects.[12]

Historical Evidence.

Historical evidence of course affects only a short period, but it should give proof, had there been considerable and continuous change in one direction. It has often been appealed to, especially concerning north Africa and Asia, and the controversies illustrate the fact that climatic changes may not have been the cause of the shifting or decrease of populations, which have been put forward as one of the strongest evidences of change.[13]

Post-Cretaceous Climates.

It is my purpose to-night to consider the South African evidence from post-Cretaceous times only, and an attempt must be made to picture the geographical conditions at the end of the Cretaceous period. The approximate position of the shore line at that time is known only in the east and south-east, where late Cretaceous shallow-water marine deposits occur near East London and are also perhaps preserved in Bathurst, Alexandria and Uitenhage.[14] Inshore deposits of a slightly earlier age are better known over a much longer stretch of coast to the north-east,[15] and early Tertiary inshore beds are known to exist in Zululand and Portuguese territory, but precise information about them is wanting.[16] The later Cretaceous beds lie on eroded surfaces of various formations from pre-Cape possibly to the Uitenhage series. South Africa had become an area of denudation rather than of deposition at the close of Karroo times, probably during the Jurassic period. The greater part of its surface was not diversified by mountains or considerable hills; some at least of the northern ranges, such as the Langeberg and Magaliesberg, were probably buried under Karroo beds, but the southern ranges of the Cape were in existence in early Cretaceous times[17] though less prominent than to-day, and the post-Uitenhage faults had the effect of increasing the relative elevation of the ranges; an approximate later limit to the age of the faults has not yet been determined. A large area south of the main watershed in the Karroo must have been covered by Uitenhage beds, but how far north of the Zwartberg-Zuurberg line they extended is not known; it seems probable, however, that the rivers going to the south, the rivers now represented by the Gouritz and Gamtoos, ran over these early Cretaceous beds for a great part of their courses. By late Cretaceous times Bushmanland had been partly stripped of its covering of Karroo deposits.[18] The average lie of the land as regards sea-level can be surmised from the present position of remnants of a peneplain in the interior of the country relatively to the known position of the latest Cretaceous shore lines, bearing in mind that the inshore Cretaceous beds rest apparently undeformed against the already bent eastern outcrops of the Upper Karroo beds in the Lebombo range.[19] It is as yet difficult to estimate subsequently produced differences in relative level due to bending as contrasted with block uplift of the sub-continent, but it certainly appears probable that the peneplain was formed at a very considerable elevation. In the Stormberg and Griqualand West this peneplain now lies some 4,600 feet above the sea and the date of its formation has been assigned to the late Cretaceous or early Tertiary.[20] Support for this view is obtained from the valley leading from Bushmanland and to Henkries on the Orange River, where Dinosaur bones were found at the bottom of a well about 3,500 feet above sea-level, buried under 110 feet of granite wash.[21] The granite floor exposed in the well must be looked upon as the floor of a Cretaceous or early Tertiary valley. No fossils have yet been found in the material forming the 4,600

foot peneplain to the east, but it seems likely that the old western land surface was continuous with the surface in which that peneplain was being cut, though it is probable that the western surface is the older of the two; that it happened to be preserved at an earlier stage for our inspection. The position of the Cretaceous shore in the west is not known; neither Cretaceous nor Tertiary marine beds have been found on the west coast south of Buntfeldschuh, but in the absence of evidence of faults of Tertiary age on the west coast one is justified in expecting that Tertiary inshore deposits await discovery south of the Orange River in positions analogous to those of Granitberg and Buntfeldschuh.

The most definite evidence of the climate under which was developed the surface represented by the 4,600 foot peneplain in the east and the buried floor of the Henkries valley in the west, comes from the latter valley, which at the time when it began to be filled in had greater depth relatively to the hill flanking it than it has to-day. It is obviously a stream-cut valley, but when the Dinosaurs whose bones were found lived there, the stream was no longer able to keep the channel open; the valley became filled in with the quartz and felspar grit through which the well was dug, and ever since then the process of accumulation has, on the whole, continued; the climate has not become sufficiently humid to supply a stream which could re-excavate the valley. The bottom of this valley is still the earliest known record of the post-Karroo land surface in the country north of the Cape ranges. Whether the thick superficial deposits on the eastern flank of Kamiesberg[22] belong to the same period is not yet known, and no corresponding discovery has been made in the Kalahari. The known position of the Karroo beds in the south-west of Bushmanland and the down-faulted outliers near the Orange River at Viool's Drift make it very probable indeed that the Karroo beds covered the Henkries valley, and the streams which removed them would seem to have had a greater supply of water than there is in that region to-day; the diminution of rainfall, if that were the immediate cause, took place in late Cretaceous or early Tertiary times. Passarge tentatively attributed part of the cementation by silica of the Kalahari sand to pre-Tertiary events,[23] and that such did take place then is rendered very probable by the close association of siliceous concretions with the Dinosaur bones in the well at Kangnas.

A few years ago very interesting observations bearing on the climate of the Namib in Tertiary times were made by Professor Kaiser and Dr. Beetz, who found "a large species of *Helix*" in the silicified rocks of the Pomona Tafelbergen, and remains of vertebrates in the marly sandstones of Elizabeth Bay, and also other fossils.[24] These have not been described so far as I know, and their discussion may be expected to give most valuable information. Professor Kaiser states that they indicate the terrestrial deposition of the beds concerned, and that these are

of about the same age as the Mio-Pliocene beds of Bogenfels. He looks upon them as the deposits formed under arid conditions upon an early Tertiary land-surface on which erosion channels had been formed. That the climate had been wetter before their deposition he considers proved by numerous solution holes and channels in the underlying dolomite which were filled in with material forming part of the Pomona beds, and also, perhaps, by the deeply weathered state of schists and quartzites under those beds, but he utters a warning against accepting deep weathering as proof of greater rainfall.

The quartzites of the Pomona beds are very like the surface quartzites of the western and southern districts of the Cape Province, but hitherto the only organic remains found in the latter[25] are obscure impressions of plants that have not been determined. Where the underlying rock is seen, it, like the schists mentioned by Professor Kaiser, is deeply weathered; numerous instances of this are to be seen in Caledon, Swellendam and Bredasdorp. The conditions under which those quartzites were formed have not been satisfactorily explained. Kalkowski's suggestion[26] that the siliceous cement was derived from siliceous grass and diatoms living in pans, has not been substantiated by the discovery of their remains in the typical quartzites, nor by the form of many of the quartzite deposits.[27] The residual clays immediately below the quartzites might be suspected to contain free hydrated alumina instead of hydrous silicates, in fact to be laterites, but this has not been proved. Laterite containing free alumina is believed to be peculiar to hot climates with marked wet and dry seasons; therefore, so far as it goes, the failure to find laterite under the quartzites is evidence against the existence of such a climate at the time of their formation. It is difficult to surmise a source of the siliceous cement elsewhere than in the underlying rock, for there is no evidence of siliceous spring water having supplied it; the wide distribution of the rocks, as well as the absence of sinter, puts that explanation out of court. The process is probably analogous to that by which tufaceous limestone is formed; it is perhaps an extreme example of the frequently-observed hardened crust on rocks which are quartzites in depth, become comparatively soft above ground-water level and again intensely hard on the outcrop, though the chemical process by which the transfer of silica is effected does not appear to be known. The bearing of these large bodies of siliceous rocks on the climatic conditions at the time of their formation is not clear. Passarge,[28] who investigated many occurrences in the Protectorate, seems to refer them to periods of increased moisture following aridity, and the fact that they are so abundant in the south and west of the Cape and in the Namib, where, though the rainfall may be low, there is heavy dew, while they are less frequent in the Great Karroo and apparently unknown in the Upper Karroo, indicates a dependence on recurrent alternation of arid and somewhat moist conditions. Kaiser attributes the abundance and variety of

silicification in the Namib to chemical weathering under desert conditions.[29]

Closely connected in occurrence and origin with the silcretes are the ironstones or ferricretes, rocks in which a large part of the cementing material is hydrated ferric oxide. Though such rock is forming to-day wherever water containing iron in solution appears at the surface and deposits iron oxide, either by the direct influence of atmospheric oxygen or through the vital activities of plants,[30] there are many bodies of the rock which are undergoing erosion and are of considerable antiquity. The condition which appears to be favourable for its accumulation is an intermittent supply of ferruginous water leaking out at the surface; in countries where rain is well distributed and rather high in amount, the delicate films of oxide of iron are either masked by other material or washed away.

A characteristic superficial deposit in dry countries is the limestone, variously called desert limestone, surface limestone, calcareous tufa or calcrete. Most rocks contain sufficient lime in the form of silicates or carbonate to yield the bicarbonate to ground water, and where the solution does not flow away, whether on account of the flatness of the ground or the small quantity of water, carbonate of lime is deposited at or near the surface of the ground. The deposit is, of course, general and thickest on flat ground and on calcareous rocks, but under exceptional circumstances where there is a leakage of water from a limestone formation on an escarpment, such as the escarpment of the Kaap Plateau, thick deposits may be found on steep slopes. The appearance of these tufas with decreasing humidity, up to a certain limit, is well illustrated in this country, both in the Transvaal and further south, as one travels westwards.[31] The tufas, especially if the conditions be unfavourable for the formation of thick deposits, will disappear when a humid climate supervenes, and in this respect they differ from the silcretes and ferricretes. The want of any sort of time scale for the formation of these tufas prevents their being of use in judging the period required for the accumulation of particular deposits, and obviously the rate must vary enormously with circumstances.[32] In very dry countries there is little limestone formed, presumably because the amount of ground water is insufficient. Probably the decrease of limestones amongst the sand dunes of the west coast northwards from Saldanha Bay is to be attributed to this.

The thick deposits of tufa in parts of the Transvaal Bushveld, the Western Transvaal, and the Kaap Plateau point to the long duration of dry conditions.

The presence of shells of fresh-water mollusca in the calcareous tufa round some of the pans[32a] which are now rarely filled with water, is evidence that conditions were favourable for their existence at times, but shelly deposits in pans are unusual, and the large pans of the Transvaal, such as Lake Chrissie, which generally contain water, seem to be very poor in

molluscan life.[32b] Some of these mollusca are at times extraordinarily abundant round small springs, such as that at Stinkfontein in the Richtersveld, where the vegetation about the spring, seen from a distance of a few yards, appears dark owing to the enormous numbers of a small *Tomichia*-like snail.[32c] The snails would seem to live in damp places, seepages round pans rather than in them, possibly on account of the fluctuating salinity of the pan water. Hitherto shelly limestones filling a former pan have not been described. The deposit of diatom earth at Bank, near Amsterdam, is not in a closed pan, but in a vley fed by springs, part of a valley tributary to the Compies River. The accumulation of common salt in pans varies greatly, and so far as this country is concerned, the subject, especially the origin of the salt, has not yet received the attention it deserves either from the economic or geological points of view. A few pans, such as Rautenbach's pan in the Kalahari,[32d] have a thick layer of salt in them; others, like the productive pans of the Orange Free State, Maraisburg and Herbert districts of the Cape, and the south-western Transvaal, appear to have a large store of salt in the brine obtained within a few tens of feet of the surface. The source of salt in these pans seems to be chiefly the Karroo sedimentary rocks on which they all lie.

Another soluble deposit found in dry regions is gypsum, and it is probably still more sensitive to change of climate towards humidity. It is an abundant constituent of the sub-soil in parts of Namaqualand.

Rivers.

South African rivers in general are characterised by their steep grades, and many of the larger have waterfalls. Such rivers are still far from having reached the smooth curve, a slope decreasing steadily from source to mouth, which is the ultimate form of a river bed whatever may be the rocks in which it is cut. Before such a result is reached the system may be disturbed by earth-movements; in the simplest case, that of a whole country being lifted or the level of the ocean falling, the readjustment necessitates the cutting down of the bed from the mouth upwards, and in the process hard rocks again find expression in falls or rapids. It is too early yet to discuss shortly the evidence for the part played by post-Cretaceous earth-movements in the development of the river grades, or to answer the questions put by W. M. Davis[33] as to the effect of a probable former greater extension of the continent to the south and west on the development of the interior plains and river systems. Regional and secular climatic differences make themselves felt in various ways; and a regional difference which is obvious in our largest river system, that of the Orange, is the greater rainfall in the catchments of the main streams, the Orange in Basutoland and the Vaal further north. These two streams supply almost all the water in the river below their confluence, in spite of their catchment being less than half of

that of the whole system.[34] The result is that below the confluence the Orange is a stranger in the desert, an allocthonous river in Penck's phrase, and is merely a channel conveying water from the east to the Atlantic without receiving noteworthy additions on the way. The erosion accomplished by the Orange River is done by this water from the east, and consequently the channel is deepened at a rate with which the lower affluents cannot keep pace, for they are periodical streams from drier regions. These tributaries are kept in a condition favourable to active downward cutting near their mouths, and are in consequence steeply graded in the lower parts of their courses.[35] The largest tributary is the Hygap or Molopo, draining some 87,000 square miles, about three-quarters of that of the combined catchments of the Vaal and Orange head streams, but the drainage basin is, in general, an arid country and it includes the southern Kalahari. When Moffat visited the mouth of the Molopo (Aintas as he called it) in 1854, he was surprised to find it only 80 or 90 feet wide.[35a] There is as yet no large scale map of that part of the country, but the contoured Reconnaisance sheet of Kakamas, published in 1914, gives some important facts. The mouth of the Hygap is about 1,500 feet above sea level, the average slope of the last six miles of its bed is 100 feet a mile, and from near Molopo Kop, 20 miles up the valley, it falls 900 feet. This is a very steep grade for the lowest stretch of a river draining a large area, and it is clearly due to the great rate at which erosion is performed by the storm water in it as compared with the slight erosion higher up. About Zwart Modder the bed rock is buried under sand for some hundreds of miles.

The principal feeders of the Hygap are the Nossob, Molopo and Kuruman Rivers, and of these the Molopo, in certain parts of its course,[36] is a trench deeply cut in quartzites, as is the Hygap at Zwart Modder. These trenches are being filled in with sand and limestone, proving that less water runs in them than at some former period. So far as I can ascertain there is no tributary from the southern Kalahari between the Nossob and Molopo; if there ever were such a river its valley seems to have been obliterated. The Molopo itself rises in the Western Transvaal, on the Dolomite, and the exposure of that formation in which rivers tend to disappear owing to the passage of the water underground through solution channels, must have affected adversely the supply to the river above Mafeking. The whole of the Western Transvaal was formerly covered by comparatively impervious Karroo rocks, at a date geologically recent, and their removal by denudation has influenced the surface drainage by allowing much of it to pass underground and escape elsewhere than down the main rivers of the area. The Kuruman river has been influenced in the same way; its chief gathering ground is the Dolomite of the Kaap Plateau, which has been denuded of its former cover of Karroo beds. In each of these instances the area of higher rainfall in the east has had its run-off diminished through the change from an impervious surface to a limestone surface which has a steadily increasing capacity

for holding water underground. The date at which the exposure of the Dolomite began is not known, but the Kuruman and Molopo still traverse Karroo beds for many miles above their confluence,[37] and it is possible that in early Tertiary times their valleys were mainly in that formation.[38] The Kuruman River has no tributaries between the confluence of the Mashowing and that of the Molopo, a distance of over 100 miles, and water flows between these points only at intervals of years.

The present state of the Molopo is sometimes regarded as conclusive proof of decreased rainfall in the southern Kalahari, even during the human occupation of the country. It is doubtful whether native tradition is strong enough to substantiate this, and the meaning of the word Molopo (a common spelling) is, according to Mr. Stigand[39] "an intermittent creek or backwater." The deeply-cut trenches and the gravels observed at certain parts of its course prove that more water ran down the valley at some time in the past than now,[40] but the development of the sandveld, which greatly diminished the run-off from the region, and the replacement of an impervious floor by dolomite in those parts of the catchment with the higher rainfall, which must have had a similar effect, may well account for the observed result without calling in a period of increased rainfall of long duration.

There have been no discoveries of fossiliferous beds which date the commencement of the accumulation of the sand in the Southern Kalahari. The remains of mollusca belonging to living species at Witkop in Gordonia[41] and at a few other places are more recent than that event. The pink and red marls underlying the silcretes in parts of Bechuanaland appear to be the oldest known post-Karroo rocks in the region, but they have as yet yielded neither bones nor shells.[42]

The Kalahari sand which covers so large a region in the Kalahari itself and has outlying representatives of great area in the Waterberg Flats of the Transvaal and in Bushmanland, and of smaller area in Kenhardt, Prieska, Carnarvon and Kimberley, is no doubt derived in part from rivers and in part directly from the parent rocks by insolation and wind transport.[43] Wind must have been the chief agent in giving it the wide distribution it now has. It is known to be 130 feet thick in places[44] south of Morokwen.

An instance of a partially sand-filled valley far from the Kalahari is the Zand Leegte in Clanwilliam.[45] This is a well-marked valley cut in the Table Mountain Sandstone of the coast belt which is gradually being filled in, and down which water has not been known to flow continuously since the occupation of the farm, over 100 years ago. The country between the Berg River and the Olifants west of the mountains flanking the left bank of the latter is a sand veld, an old land surface buried to a considerable depth under sand through which the tops of hills project; 40 feet was considered a low estimate of the average depth of sand. The presence of a raised beach containing shells of living

species south of the mouth of Zand Leegte and about 100 feet above the modern beach proves a recent date for the infilling of that valley, and the only apparent initial cause is a decrease in the rainfall in that region, though no doubt the accumulation of sand over the catchment added greatly to the effect of decreased rainfall by diminishing the run-off.

In the Transvaal the minor valleys often head in kloofs partly filled with gritty alluvium or wash in which the present stream bed is entrenched to considerable depths, 20 to 50 feet, without exposing the bed rock of the valley. The Kloof at Heidelberg is a good instance, and the stream leading to the Crocodile River on Wachteenbietjesdraai, in Rustenburg District, is one from country only lately in permanent occupation by Europeans. A marked effect of permanent occupation by whites is the destruction of vegetation in stream beds, thereby giving freer scope to the erosive power of the stream. So instances of the kind we are now concerned with are not free from uncertainty, but the development of the ravine in the kloof on Wachtenbietjesdraai can hardly have been influenced in this way, and it points to an arid period having followed the formation of the kloof and having brought about its partial infilling by wash, which is now being removed by a deeply entrenched periodical stream.

PANS.

Pans are found chiefly in dry regions, for in wet countries any depression from which there is no outlet is eventually filled in with mud and sand carried there by water, or else the depression becomes part of a river valley. They are most numerous in the drier parts of South Africa, and especially in the dry country now occupied by nearly horizontal Karroo beds or but recently stripped of them. In the Ghoup and Tanqua Karroo, with an average rainfall of less than 10 inches, and where the Karroo beds are inclined at various angles, there are no well defined pans,[46] but in the northern Karroo of Calvinia, Carnarvon, Prieska and Hopetown, where the rainfall is about the same and the rocks lie flat, well developed pans are numerous, as they are in the Western Orange Free State and the Southern and Eastern Transvaal. In these latter regions the rainfall is higher than in the Karroo, from 15 to 35 inches instead of from 5 to 15,[47] and twelve years ago Professor Penck argued that the salt-pans of the Transvaal and Orange Free State were formed when those parts of the country had a drier climate than they now have, because such depressions cannot develop in a humid climate.[48] The most remarkable pans in the Transvaal are those in the Ermelo District, of which Lake Chrissie is the best known. They lie entirely on Karroo beds, and they are on the great watershed between the Vaal River, the Komati and Usutu Rivers. They are well defined pans, for the vegetation changes in character within a few yards, while in the pans of the Northern Cape Province the zone of change from pan-floor to outer veld may be 100 yards wide. Many of the smaller pans support a

thick growth of reeds which project a few feet out of the water even where the pan is well filled. These Eastern Transvaal pans are entirely out of harmony with present conditions. The surrounding country, made of sandstones and shales, furnishes sand and mud to the pans, and the cover of vegetation must prohibit or greatly hinder wind erosion on the pan floor. The average rainfall at Lake Chrissie is, according to Mr. Stewart, about 33 inches, and it is very difficult to conceive how the pans could have been formed in such a climate. The pans near Heidelberg in the Southern Transvaal[49] are almost as hard to account for as those of Ermelo; during my residence of over three years at that place the larger pans held water continuously, and the smaller when dry were thickly covered with vegetation. Penck's hypothesis of their formation during an arid period in that region is at least well founded.

A Pluvial Period?

Passarge has laid stress on a former Pluvial period in South Africa contemporary with the Pleistocene Ice Age,[50] and in fact the notion of a Pluvial period is closely bound up with a theory of the Ice Age, according to which the lowering of the snow-line and advance of glaciers were coincident with and in part due to heavier precipitation. But Penck has shown that the recorded depressions of the snow-line do not indicate that in regions of heavy precipitation at the present time there was a greater lowering of the snow-line than elsewhere during the Ice Age, as there should have been had heavier precipitation been connected with the extension of the snowfields.[51] He has also shown that in North America the Great Salt Lake, in the neighbourhood of a formerly glaciated region, bears evidence of a contemporary high water level and an outflow, while further south amongst the bolsons or pans of Nevada and California corresponding high level and deserted shore lines do not exist.[52] He concludes that the limit between the arid region and that of greater precipitation to the north was further south than it is to-day by about 5° of latitude; that there was no world-wide Pluvial period, but that the great climatic regions were in different positions; that the desert belts were nearer the Equator. He points out that evidence for this shifting of the belts is to be gathered from North Africa, and lately R. Chudeau has demonstrated that the North African desert in Pleistocene times lay over the Northern Sudan and has since then moved northwards into the Sahara.[53] Penck emphasised the fact that temperature controls humidity; that, for instance, under similar conditions of rainfall and topography, lower temperature means less evaporation and greater run-off. The contemporaneity of lowered snow-lines in Europe and Central Africa is not proved, but it is probable that the period when the glaciers of Kenya descended 5,000 feet lower than they do now coincided with part of the Pleistocene Ice Age of Europe;[54] in any case, the lowering of temperature in Central Africa probably implies a contemporary lower temperature in South Africa, even

though there were no glaciers here. The reason for the absence of Pleistocene glaciers in South Africa has not been found; perhaps the precipitation was too small and took place, as now, chiefly during the summer months, but the effect of the lowered temperature must have been an increase of flowing water in what are now occasional rivers; possibly some of those in the Karroo and Southern Kalahari became permanent streams for a long period. There is some evidence of a shifting of the dry belt southwards in times not remote in a geological sense both in the distribution of pans, as noted above, and in the fact that the sand region of the Kalahari is now covered with vegetation, which has been taken as evidence of former drier conditions in that country.[55] This presumed southerly shift of the dry belt implies that the region of the Great Karroo is drier now than it was in Pleistocene times, and there may be evidence of this in the imperfectly developed pans and in the depth of alluvium which is a striking feature in many poorts of the Karroo rivers.[56] The great difficulty here is to get adequate evidence of the time relation of the various events in different regions, but this will eventually be overcome; and there is an element of uncertainty in attributing the silting up of river beds to climatic change, for lowering of grade due to tilting or the erosion of the bed above a given place will have much the same effect by reducing the velocity of the current, and possible alterations in the conditions such as these can only be eliminated from the argument by detailed consideration of groups of streams.[57]

In the Salt Pan north of Pretoria there is preserved a record of the Bushveld climate for a long period. The pan occupies a caldera, a pit of volcanic origin, and its floor lies 200 feet below the level of the surrounding Bushveld. The great interest of the caldera consists in its being a depression formed during post-Karroo times, probably at a much later date than the pipes filled with kimberlite, and in its never having been filled with water to overflowing; thus the record of the history of the caldera considered as a large basin holding a solution can be read by the application of a knowledge of physical chemistry. Dr. Wagner has lately made a detailed investigation of the pan and has arrived at some conclusions important to our subject. He found that the mud separating layers of trona contains diatom shells, and that the water, at times fresh enough to allow diatoms to live in it, deposited at intervals the layers of trona which indicate the concentration of the lake waters at those times, while the intercalated diatomaceous muds were formed during more humid periods. The final desiccation of the pan led to the deposition of a crust of common salt and to the drying out of the muds and clays to a depth of at least 29 feet; the more humid conditions now prevailing keep the muds and clays underlying the floor saturated with water, the dry clays mentioned being apparently sealed off by impervious layers, and the common salt is for the most part held in solution, for the water now rarely or never entirely disappears by evaporation.[58]

Evidence of Plants and Animals.

The evidence of climatic conditions afforded by the remains of plants and animals in this country during post-Cretaceous times is very meagre. The only plants yet found which belong to that long period are the siliceous rocks of Komgha containing oogonia of *Chara* as well as gastropods of fresh-water type; the obscure plant markings in the surface quartzites of the Cape Flats; some silicified wood in Bushmanland, the undetermined leaves in the Knysna lignites, and the diatoms in certain limestones in the Kalahari.[59] No useful information has been got from them. The few discoveries of extinct late Tertiary or Quarternary land-animals in the Vaal River gravels and elsewhere[60] throw no fresh light on climate; they could, so far as we know, exist under present conditions. There are a few marine shells in the raised beach deposits of Little Brak River which are not found in the adjoining sea, but which are still living in warmer water on the east coast.[61] Whether the presence of these shells indicates generally warmer water on the south coast at that time, a greater volume of the Mozambique current, or merely record a change in the area occupied by the species may be difficult to decide.

The enormous numbers of large mammals in South Africa and the apparently scanty vegetation is discussed by Charles Darwin in his Journal.[62] He unfortunately never saw the interior of the country, for he travelled inland only a few miles from the coast, and he had to depend on the observations of naturalists like Andrew Smith and Burchell as well as of earlier travellers. Darwin quotes the conditions in South Africa as directly contradicting the prejudice, derived from the East Indies, that large animals require luxuriant vegetation, and as indicating that the surroundings under which lived the abundant animals whose remains were found at Punta Alta in South America may not have differed much from the present desert in that neighbourhood. It has been said that the bones of hippopotamus, rhinoceros, eland and quagga found in the alluvium of Karroo rivers indicate that tropical animals, requiring vast amounts of food, formerly lived there and that they could not live there now.[63] This is an entirely unwarranted conclusion; the animals mentioned are not peculiar to the tropics, and there can be no doubt that but for the spread of the destructive combination of man, the dog and the gun the Karroo and the Fish River valley would now have as many of these animals as they had four or five generations ago. The fact is that the prolonged coexistence in any area of a farming population and great game is impossible. What happened in the Karroo in the 18th and the first half of the 19th century is happening in our time in the Waterberg and other districts which are not yet closely settled. It has long been recognised that the advent of man with his adaptability and mental power, which he has not yet learnt to use without detriment to his descendants, is a very potent factor in the change of other inhabitants of a country and of its surface. He increases the run-off not only by burning vegetation generally and destroying it along narrow

tracks but by incidentally or purposely removing obstacles to erosion and water-transport in river channels.[64] A large part of these effects of human occupation is unavoidable, and only the increasing value of land which accompanies a growing population will compel men to take proper care of it.

Occasionally one comes across a striking piece of evidence of the adaptation of the higher animals to the varying conditions in their surroundings, and one such was the discovery by Mr. Marais in 1913 of a crocodile and many fish living but buried deep in the dry bed of the Magalakwin.[65] The habits of the *Protopterus* of the Zambesi basin are another example. Such instances prove that the ancestral experience of these animals had forced the survivors amongst their descendants to learn to cope with the severest droughts affecting their habitat. They are also proof that any particular drought during which the animals are found alive in their refuge is not necessarily the worst yet experienced, otherwise they would not be found alive.

The gradual changes in the distribution of plants afford evidence of changes of climate, or of conditions of which climate is a factor. The level of the ground-water, for instance, depends upon climate, the nature of the ground and the facilities for sub-soil drainage; if the latter be greatly increased by the development of dongas or by the multiplication of wells, the level of the ground-water falls, and this will affect the distribution of plants, for those with short roots may no longer be able to maintain their footing. Changes of this kind may well be of importance in determining the limit between predominantly grass and bush veld in a region like the north-eastern Karroo, where there is a very fluctuating rainfall and the conditions are favourable to the erosion of dongas. In such a region, as in the Great Karroo, the establishment of hundreds of farms, each with one or more wells or boreholes from which stock are watered throughout the year, whereas before the advent of the white farmer pools or streams served the antelopes and other wild animals which migrated elsewhere when the veld failed them, must have a lowering effect on the ground-water level apart from the influence of dongas and the artificially increased erosion of the stream beds.

An interesting description of the increasing drought between 1904 and 1916 in the drainage basin of the Swakop and Khan Rivers has been written by Professor F. Jaeger,[66] who states that the desert conditions of the Namib gradually stretched inland beyond Karibib to Johann-Albrechts Höhe, but that from 1917 the reverse change took place, a great part of the Namib itself becoming covered with grass. No doubt the work done for the newly instituted Botanical Survey, for the permanence and success of which all members of this Association will hope, will discover in the course of a few decades changes of various kinds in the veld flora, and may make it possible to assign certain changes to altered physical conditions. When we think how valuable it would be to have now an accurate account of the plants and their approximate relative abundance in any half-dozen areas of

varied condition 100 years ago to compare with what exists to-day, it is obvious that the Botanical Survey will in time throw light on many obscure questions of distribution and their connection with changed conditions of all kinds.[67] No doubt much evidence of this sort is to be found in the botanical literature, but I am only able to mention two instances. In a paper read before this Association in 1916 Mr. J. S. Henkel describes the extension of forest over certain areas in the Drakensberg and ascribes it at least in part to protection from fire.[68] In his presidential address to Section C in 1920 Dr. T. R. Sim shows that in the limiting region between Karroo and grass-veld the former is gaining, on account of injudicious use of the veld and possibly also on account of drier climatic conditions.[69] The former is a known cause, but the latter is not yet proved as regards the actual amount of rainfall.

Historical Evidence.

The written history of the interior of South Africa goes back less than 300 years; the details recorded at an early date about its climate and water supply are naturally meagre, and the conditions then prevailing have generally to be surmised from incidents of travel such as the facilities of obtaining water and grazing for animals. Occasionally we find a considered statement about the conditions of the country from the point of view of a Government desirous of increasing the white population; a valuable statement of this kind is that of Commissary General de Mist in 1801, who said that on a journey from the Olifants River in the west to the district of Graaff Reinet the line of country traversed would be found to consist of a series of barren deserts and Karroo on which not a morsel of food could be found for man or beast, and that the more valuable country to the east was already occupied by natives.[70] De Mist would no doubt be surprised at the farming now done from Van Rhyns Dorp eastward to Middelburg, but his opinion is evidence that the country he mentions had the same kind of climate 120 years ago as it has to-day.

A general statement of later date, concerning the character of the country granted to the Albany Settlers, is quoted by George Thompson;[71] it is pointed out that uncertain rains in the east as compared with the west rendered the district chosen unsuited to the 100 acre allotments made to the poorer class of settlers.

The diary of Simon van der Stel's journey to Koperberg in 1685 gives a very good account of the facilities of travelling in the western districts of the Cape; the barren nature of the country in what is now called the Harde Veld, which is rather surprising as the journey was made in September, when the veld is generally in good condition now; the frequent finding of brak or salt water and the scarcity of fresh; the description of the small spring at the Koperberg itself and the dry river beds, just as we find to-day; and the drying up of various small waters before the return journey in November, when they had to dig for water in Buffel's River, where in October they had found

shallow brak water. With the very important exception of the many wells and protected water holes since made in that area, the facilities for obtaining water then were evidently no greater than to-day.[72]

Of the state of the Karroo in the eighteenth century we have accounts by Le Vaillant, Sparrman, Paterson, Thunberg and Barrow, though they visited the country late in the century.[73] Their descriptions would apply closely to what one finds to-day, if one makes allowance for the settlement of the country and the consequent opening of springs and wells, which enable the traveller to go practically where he likes at all times of the year; and another conspicuous effect on some of the rivers is due to erosion caused by overstocking and the destruction of reed beds. Beer Vley, which Barrow found to be " a delightful spot in the midst of a barren desert, affording shelter, food and water " at the end of July, 1797,[74] when revisited on his return journey from Graaff Reinet in December, Barrow expecting, on account of the heavy rain which had just fallen, to find plenty of water " at least as far as De Beer's Vley, the delightful meadow in the Desert," provided scarcely enough water for his horses and none for his cattle.[75] He wrote: " The great scarcity of water on those plains of Africa known by the name of Karroo, rendering it sometimes hazardous, and almost always harassing, for the cattle to pass, should seem to point out the camel or the dromedary as the kind of animal best suited for the transport of goods and passengers in the Colony of the Cape." In reading these accounts of the difficulties experienced by travellers in the Karroo 100 years or more ago one is struck by the very hard things said about it, but the problem of transport in the Karroo has long since been solved by the replacement of oxen by donkeys, and of course by the gradual settlement of the country, the improvement of roads, the digging of wells, and the opening of small fountains and boreholes.

Lichtenstein and Burchell travelled early in the nineteenth century and wrote very clear accounts of the Karroo.[76]

Comparing my own experience of the Karroo, from the Fish River Valley to Calvinia, with the narratives of travellers written more than 50 years ago, my conclusion is that no deterioration of climate nor marked loss of water has taken place. Had the country become drier than it was in the descriptions of Burchell and others, the numerous farms we find in it could not have been established; but allowance must be made for the impression conveyed to travellers who were probably unused to dry regions, and for the obvious fact that the better-watered district of Sneeuwberg and Graaff Reinet would be settled earlier than the Ghoup, so the opinions of the early travellers no doubt exaggerated the difficulties of the country.

Of the Transvaal and Orange Free State there seem to be fewer early narratives by travellers than of the Cape. The general impression is that water is less abundant now than thirty or eighty years ago, but the narratives of Gordon Cumming and

Harris, who travelled in the thirties and forties of last century with wagons and had little difficulty in crossing the Limpopo and other rivers as they came to them, do not suggest that there has been a great change.[77]

The Middle Kalahari.

It is beyond my purpose here to discuss the very incomplete evidence we yet have about the existing features of the middle Kalahari with the Makarakari and Ngami basins. They probably are flat regions with ill-defined drainage, in which heavy rains produce extensive flooding; they are probably typical results of an arid climate, the duration of which is to be measured in geological periods; had they been a country with heavy precipitation throughout a long period of recent date, one would expect a definite drainage towards the Zambesi, Limpopo or other direction to have been established, whereas there still seems to be indecision, as instanced by the stoppage of the flow of the Tauche by the reed rafts of the natives.[78] The supposed recent drainage of the area by the sudden opening of the Batoka Gorge is contradicted by the gradually increased bevelling of the edge of the gorge and the progressively increasing length of the tributaries below the falls.[79]

Conclusions.

The conclusions these various lines of evidence point to are that during post-Cretaceous times the climate of South Africa has fluctuated within rather narrow limits; that there has not been a Pluvial period, if by that term is implied a long period of much greater rainfall over the whole country; that a general lowering of temperature in the Pleistocene may have given the Karroo and Southern Kalahari rivers longer periods of flow, but that this more humid era in those regions had come to an end long before human evidence can be drawn upon for an account of it; and that South Africa, like North Africa, the Americas and Australia,[80] bears witness to a shifting of the climatic belts in Pleistocene and subsequent times.

NOTES.

(1) P. C. Sutherland, "On the Geology of Natal (South Africa), being a Paper read before the Natural History Association of Natal, on the 27th June, 1868," Durban, 1868. It is of interest to note that Dr. Sutherland's opinion was supported and apparently prompted by Andrew Ramsay's explanation of the Clent breccias of Permian age, which was a mistaken one. The latest paper on the Karroo glaciation is "The Carboniferous Glaciation of South Africa," by Dr. A. L. du Toit, Trans. Geol. Soc. S.A. XXIV, 188-227, a comprehensive summary of the facts and an explanation on the lines of Wegener's hypothesis.

(2) F. B. Taylor, "Bearing of the Tertiary Mountain Belt on the Origin of the Earth's Plan," Bull. Geol. Soc. America, XXI, 179-226, 1910. A. Wegener, "Die Enstehung der Kontinente und Ozeane," 1915, 2nd edition, 1920; also a summary by that author in "Discovery" for May, 1922.

(3) A. L. du Toit, "Land Connections between the other Continents and South Africa in the Past." South African Journal of Science, XVIII, 120-139.

(4) A. Daubree, "Etudes synthétiques de Géologie Expérimentale," 1879, p. 256.

(5) The effects of climate on rock formation are discussed in many works; a comprehensive discussion of moderate length is that by Joseph Barrell, "Relations between Climate and Terrestrial Deposits," Journal of Geology, XVI, 1908. Johannes Walther in "Einleitung in die Geologie," 1893-4, especially Vol. III, treats of the subject in detail; in "Denudation in der Wüste," 1891, and "Das Gesetz der Wüstenbildung in Gegenwart und Vorzeit," 1900, he deals specially with dry climates.

(6) W. M. Davis in a paper entitled "The Geographical Cycle in an Arid Climate," Journal of Geology XIII, 1905 (reprinted in "Geographical Essays" 1909), discusses the question at length, and in the volume of collected papers will be found admirable presentations of the evolution of surface forms through various agents.

(7) Prof. J. W. Gregory considers the term "Inselberg" unnecessary ("The Rift Valleys and Geology of East Africa," 1921, p. 35) and would call the hills residual mountains, which they are, tors or monadnocks. He says that the term would be more appropriate for an inlier like the Isle of Ely; it seems to me unlikely that anyone having a recollection of that place and seeing the Inselberge of South Africa would use the same name for them as physical features. Brent Knoll, rising abruptly from Sedgemoor, would be a closer analogue to some of the island mountains of Bushmanland and the southern Kalahari, for their bases are certainly buried, sand taking the place of the alluvium of Sedgemoor. But there is a great difference in appearance owing to the fact that the island mountains are made of hard rocks and owing to the difference between the agencies of erosion and transport in the two regions. Rocks like the soft Jurassic clays and limestones of Brent Knoll would scarcely become Inselberge in the Kalahari. It sems convenient to retain Bornhardt's term, which has become widely known through its adoption by Passarge, for a special class of residual mountains, just as certain other residual mountains with their bases buried in ice are called nunatakkr. Inselberge lack the curved profile produced by stream erosion, their profile is chiefly made up by straight lines, in which again they resemble nunatakkr and for analogous reasons, disintegration by change of temperature and transport of the fragments chiefly by gravity and wind, almost without the co-operation of running water.

(8) "Die Kalahari," pp. 636-7. Descriptions of several of the plains are to be found in this book; that of the Kwabe district on p. 114 and previous pages is one of the best. It must be remembered that work further south has proved two periods of erosion of pre-Cretaceous age, one of early Nama and the other of early Karroo age. It is scarcely possible without detailed work to be assured that in any particular instance we are concerned with the results of the latest of these three periods alone. At the time of Passarge's work in this country (1896-8) the widespread occurrence of Karroo outliers north of the Orange River had not been recognised, and very little was known of the nature of the pre-Nama floor.

(9) It would be convenient to confine the term "pan" to depressions lacking outlet, but the local usage is not uniform; the largest depression in this country is Haakschien Vley, while one of the largest depressions connected with a river is called Verneuk Pan, though ordinarily what are called pans have no outlet and a vley is part of a valley.

(10) Descriptions of Haakschien Vley and other pans lacking outlets are given in Ann. Rep. Geol. Comm. for 1907, pp. 110-120; of Verneuk Pan, with outlet, in Trans. Roy. Soc. S.A. 1911, pp. 79-82. Also in the Reports for 1906, pp. 82-5; and 131-4; for 1907, pp. 190-2; for 1910, pp. 13-6.

See also Passarge, "Die pfannenformigen Hohlformen der suedafrikanischen Steppen," Pet. Mitt. 1911, 11, Heft 2. H. Michaelsen, "Zur Kenntnis der Kalkpfannen des oestlichen Damaralandes." Naturwissen-

schaftliche Wochenschrift, Dec. 1910, p. 773, and "Die Kalkpfannen des oestlichen Damaralandes," Mitt. a.d. deutsch. Schutzgebieten, 1910, Heft 3.

(11) Passarge, "Die Kalahari," pp. 497, 660, and Chapter XVII. The origin of pans through erosion and transport by animals was clearly argued by M. S. Alison in Trans. Geol. Soc. S.A. Vol. IV, 1899, pp. 158-161.

(12) See the discussion on pp. 238-241 in W. B. Wright's "The Quarternary Ice Age," 1914.

(13) J. W. Gregory, "Cyrenaica," Geographical Journal, May, 1916, especially pp. 337-9. The causes of the depopulation of Iran are briefly discussed in "Turkestan," 1905, by E. Huntington, who emphasizes the climatic factor. The same author has a most interesting chapter on "Climate and the Evolution of Civilization" in "The Evolution of the Earth and its Inhabitants," by Joseph Barrell and others. Newhaven, 1919.

(14) H. Woods, Ann. S.A. Museum, vol. VII, 1908, p. 13. E. H. L. Schwarz, Trans. Geol. Soc. S.A., vol. XI, pp. 107-15.

(15) For references to descriptions of these Cretaceous rocks see pp. 327-343 of "Geology of Cape Colony," by A. W. Rogers and A. L. du Toit, 1909; Wm. Anderson's Three Reports of the Geological Survey of Natal and Zululand; R. Bullen Newton in Trans. Roy. Soc. S.A., vol. I, pp. 1-106; and W. J. Plows, Annals of the Durban Museum, vol. III, Part 2, 1921.

(16) R. Bullen Newton, "Notes on Nummulitic Limestone in South-East Africa (Gazaland)," Geol. Mag. 1896, 487-8. Wm. Anderson, Third Report of the Geological Survey of Natal and Zululand, 121-130.

(17) A. W. Rogers, "The Geological History of the Gouritz River System," Trans. S.A. Phil. Soc., XIV, p. 4. The pre-Uitenhage date of the Worcester Fault accepted in that paper was disproved by R. H. Rastall, Q.J.G.S., 1911, pp. 701-732, and Dr. du Toit informs me that on a recent visit to the conglomerates on the north side of the fault he satisfied himself that they were not of Uitenhage but of much more recent date. This proof of the post-Uitenhage age of the fault increases the probability that the Uitenhage beds covered at least the lower summits of the southern ranges.

(18) A. W. Rogers, "The Occurrence of Dinosaurs in Bushmanland," Trans. Roy. Soc. S.A., vol. V, 1915, pp. 247-272.

(19) This can hardly be said to be established by published evidence, but from Wm. Anderson's reports previously mentioned and verbal information from Mr. W. J. Wybergh and Dr. du Toit it is very probable.

(20) A. L. du Toit, "The Evolution of the River System of Griqualand West," Trans. Roy. Soc. S.A., vol. I, p. 355.

(21) A. W. Rogers, "The Occurrence of Dinosaurs in Bushmanland," Trans. Roy. Soc. S.A., vol. V, pp. 265-272.

(22) Ann. Rep. Geol. Com. for 1911, p. 75.

(23) S. Passarge, "Die Kalahari," p. 649. "Should it turn out that the Kalahari limestone on the Lower Kwando is actually penetrated by basalt, that will point to the relatively great age of the limestone, for the youngest great eruptions in East Africa belong to the Pliocene. (It is very probable that the basalts belong to the Batoka group, *i.e.*, that they are of Stormberg age.—A. W. R.). The silicification (Einkieselung) of the Kalahari sand would then be pre-Tertiary and, as is not improbable, the energetic transgression of the upper Cretaceous sea might have brought about increased precipitation in South Africa, which is not difficult to understand. However, if, as one is justified in doing, one relies on fossils for the determination of date, the Kalahari limestone must be relegated to the Pluvial period in the upper Pliocene, and the Kalahari sand to Diluvial times. In that case the whole Botletle period with its cementation and replacement by silica, the formation of calcareous tufas and salt pans,

falls into the period between upper Cretaceous and upper Pliocene, including upper Cretaceous."

(24) E. Kaiser, "Bericht ueber geologische Studien waehrend des Krieges in Suedwestafrika," Abh. der Giesener Hochschulgesellschaft, II, 1920. The oldest of the superficial deposits yet found in the Namib would seem to be very considerably younger than those containing Dinosaur bones at Kangnas; the observations so far recorded do not require the assumption of a wet climate in the Namib in Miocene times; they point, as Prof. Kaiser remarks, to the Miocene being the latest date to which the setting in of arid conditions there can be ascribed.

(25) The chalcedonic rock near Komgha which contains *Chara* and mollusca is not of quite the same kind as those referred to; it is a rock in which silica has replaced other substances rather than being cemented sand, and it is more like the rocks described by Mr. Bullen Newton from Rhodesia in Ann. and Mag. Nat. Hist., March, 1920, to which he tentatively assigned an upper Cretaceous age, which seems scarcely justified by the evidence.

(26) E. Kalkowsky, "Die Verkieselung der Gesteine in der noerdlichen Kalahari," Mitt. a.d. Koenigl. Mineral.-Geolog. Museum, etc., in Dresden, 1901, pp. 66-7. Passarge, in "Die Kalahari," p. 509, points out that the facts from that region are not explicable on such grounds, but that another source must be looked for and suggests silica brought in by springs. These discussions relate rather to silicified (verkieselte) rocks than to rocks made of sand grains cemented (eingekieselte) by silica.

(27) In "The Geology of Cape Colony," 1904, p. 363, Kalkowsky's explanation is said to fit in with the sporadic occurrences of the rock, but many other occurrences do not support it, notably the extensive silcretes on the flanks of Zwartberg and elsewhere (*e.g.*, Schwarz, Ann. Rep. Geol. Com. for 1905, p. 51), the small masses of similar rock associated with ferricretes at Woyenthin, Transvaal ("Explanation of the Geol. Map of the Country near Heidelberg," 1922, pp. 69-70); and such instances as that near Moorreesburg Station described and figured in "Geology of Cape Colony," 2nd edition, 1909, p. 382, which are irregularly shaped bodies of the quartzite formed in or just below the soil.

(28) Passarge, "Die Kalahari," pp. 285, 350, 370, 473, 582, and Chapter XXXV. Opaline silica is much more abundant in the rocks described by Passarge than in those of the west and south of the Cape Province, and that is also the case with the southern Kalahari and Bechuanaland occurrences (Ann. Rep. Geol. Com. for 1907, pp. 81-2); G. W. Lamplugh, in "Geology of the Zambesi basin," Q.J.G.S., vol. 63, pp. 198-200, suspects that the formation of the Zambesi silcretes goes on at the base of sands where it is exposed, and shows that it is not so extensive as the sands themselves.

(29) E. Kaiser, "Bericht ueber geologische Studien, etc.," 1920, pp. 20 and 33.

(30) In the wet years 1917-8 the deposition of iron oxides at the surface of the ground was conspicuous in Heidelberg, Tvl., at places where there is generally no seepage. The rainfall, as Mr. Stewart tells me, was 44 and 40·8 inches in the two years, while the average is about 28. "Explanation" of the Geological Map of Heidelberg, 1922, p. 69. These deposits are not quite like the iron pans formed in soils, of which a good account is given in R. H. Rastall's "Agricultural Geology," 1916, pp. 140-3. The ironstone of the Cape Flats is a pan formed under sand.

(31) W. J. Wybergh, "The Limestone Resources of the Union," Geological Survey Memoir No. 11, pp. 14-17, and vol. II, pp. 32-35.

(32) An instance of the formation of three feet of tufa in 27 years at a place where water oozes out is quoted in Ann. Rep. Geol. Com. for 1906, p. 79.

(32a) Instances are Water Pan in Vryburg (Ann. Rep. Geol. Com. for 1907, p. 111); Klein Chwaing (the same for 1906, p. 83); and the Britten Salt Pan, where the shelly tufa occurs several feet above the level of the pan.

(32b) In 1919 I looked for snails in some of the Chrissie group of pans but failed to find any, though the pans were full of water and had been well supplied with water for some years. Mr. T. G. Trevor tells me that Lake Chrissie was nearly dry between 1903 and 1906, and that it was dry at times; see a paper by him, "The Physical Features of the Transvaal," in Papers read at the joint meeting of the Brit. Association and S.A.A.A.S. in 1905, vol. I, pp. 335-350.

(32c) The shells were seen at the Stinkfontein spring in June, 1913. Owing to decomposition setting in amongst a large number collected in weak spirit they were never determined.

Vogel Vley in Calvinia has a deposit of *Tomichia* shells on a part of its border; the deposit is mentioned by R. Moffat, Journ. Roy. Geogr. Soc., XXVIII, 1858, p. 184, as a marl bed, but its mode of occurrence has, so far as I know, not been described. Specimens reached the South African Museum many years ago.

(32d) Ann. Rep. Geol. Com. for 1907, p. 119.

(33) W. M. Davis, "Observations in South Africa," Bull. Geol. Soc. of America, vol. 17, 1906, Origin of the Veld, etc., pp. 435-444.

(34) Mr. E. H. Banks kindly measured for me the areas of parts of the Orange River system above the confluence of the Molopo (Hygap) and Orange.

	Square miles.
Nossob and Auob	40,000
Molopo (including the Kuruman River)	47,000
Orange River, made up of the Hartebeest and Brak Rivers	50,000
Orange and Vaal Rivers	124,000
	261,000

(The Vaal basin is 75,000 according to W. van Warmelo, in "Irrigation Magazine," vol. I, p. 111).

In choosing a northern limit for the Molopo catchment only a narrow strip on the right bank above the confluence of the Nossob was included.

(35) The condition of the Hartebeest River is briefly shown in "Verneuk Pan," Trans. Roy. Soc. S.A., vol. II, pp. 79-82.

(35a) R. Moffat, "Journey from Little Namaqualand eastwards along the Orange River," Journal of the Roy. Geogr. Soc., 1858, vol. XXVIII, pp. 174-187. On p. 187 he attributes the fact that the Aintas supplies the river with least water of all the tributaries to the prevalence of sand in the catchment.

Though unconnected with my subject, I want to draw attention to his statement on p. 180 that he "found . . . a formation evidently subcumbent to the above saliferous shales, the lowest stratum of which was a conglomerate resting on abraded and polished granite, and filling what seemed to be a depression in the metamorphic rock." He was evidently looking at the Dwyka tillite, but there is no hint of its recognition as a glacial deposit. This was near Jonker Water in Prieska. The paper, as well as the one printed immediately before it, by the same author, is well worth reading to-day.

(36) Ann. Rep. Geol. Com. for 1907, pp. 12 and 156.

(37) Descriptions of the Karroo beds of the region are given in Ann. Rep. Geol. Com. for 1907, and in a paper by A. L. du Toit "Notes on the Karroo System in the Southern Kalahari," Trans. Geol. Soc. S.A., 1916, vol. XIX, pp. 1-13, in which the structure is made out in considerable detail from the results obtained in boring for water along the Kuruman River.

(38) On the Kaap Plateau silicified wood from the Karroo beds is still preserved in a hardened gravel at Mahura Muthla at an elevation of about 4,600 feet above the sea; Ann. Rep. Geol. Com. for 1906, p. 77; see also the same for 1907, p. 155.

(39) A. G. Stigand, "Notes on Ngamiland," Geographical Journal, 1912, pp. 376-379.

(40) A. L. du Toit, Ann. Rep. Geol. Com. for 1905, p. 255; for 1907, p. 96; P. A. Wagner, Report of the 16th Annual Meeting of the S.A.A.A.S., 1919, p. 187. The Hygap traverses a region where rounded boulders are set free from a rather soft matrix of Dwyka tillite, and therefore gravels are apt to be better developed along it than would otherwise be the case.

(41) L. Schultze, "Aus Namaland und Kalahari," Jena, 1907, pp. 706-7, and Ann. Rep. Geol. Com. for 1907, p. 107.

(42) Ann. Rep. Geol. Com. for 1907, pp. 106, 151, 156.

(43) Passarge, who had seen wide areas of this sand summed up his views in "Suedafrika," 1908, p. 60, in this way: "The Kalahari sand is the characteristic formation (amongst the younger deposits of the interior). Thick masses of red and white sand cover the greater part of the Kalahari steppes and condition their physical nature. They may well be mainly desert deposits of great age, but they were in part redistributed by rivers in the Pluvial period." This seems to be a better-founded opinion than the one expressed on p. 373 of "Die Kalahari," 1904: "Thus we always return to the notion that the Kalahari sand owes its distribution in the first place to water, and fast flowing water. The period of the Kalahari sand must have been a time of huge precipitation, which covered wide stretches of the land with raging waters. I freely admit that I have armed myself to the utmost against such a view, and that I am even now at a loss when I try to picture to myself the appearance of the country at that time. But the most varied phenomena in different regions of the Kalahari speak only too plainly for such an abundance of water." There is a note of exaggeration in this, but, provided that "period" may mean a few days or hours, the picture, though difficult to raise, is fully justified. In 1894 there was very heavy rain in Bechuanaland, and Mr. L. G. Mayers informed me that he was on the road between Grootfontein and Vryburg at the time, and that for hours, over a distance of fully 60 miles, he travelled in water inches deep with the bush projecting from it. He told me this in 1906, and in answer to a recent letter of mine in which I had asked for confirmation or correction of my recollection of his account, he writes: "I was only able to distinguish the road by the flow of the water in it, which resembled a river, the rest of the country being like a lake out of which the 'aars' (slight ridges of surface limestone marking the courses of the dolerite dykes—A. W. R.) stood forth as the only recognisable features in the landscape. The year before last (1920) much the same thing occurred again, the whole country flooded, houses falling down, horses drowned in harness on the road, and an enormous loss of stock." It was in 1904 that Abiquas Puts was converted into a lake for several months and contained large fish. Such a flood must have moved large quantities of sand in a short time. An instance of a flood causing the removal and deposit of sand is found in the Matlabas River during 1909. Before 1909 the river, as Mr. Heyzak, of Welgevonden, informed me, had pools at intervals in the dry season, but heavy rain in the catchment brought down sand during a storm in 1909, filling the pools, and water is now only seen during the winter months where outcrops occur; elsewhere it has to be dug for. This is a good instance of the silting up of a river bed without any permanent change of climate in the region. Whether there were special circumstances, such as extensive burning of grass in the catchment, depriving the sand of part of its usual protection, I do not know. In September, 1920 (*i.e.*, at the end of the dry season), the Matlabas was the only one of the four northward flowing rivers (the others are the Pongola, Palala, and Magalakwin) seen by me that was dry, the other three had flowing water.

Though there is no doubt that great quantities of sand may be transported by water within a few hours in the usually dry country of the interior, it is probable that wind is by far the more important agent, because on the rare opportunities one has of seeing vertical sections through the sand bedding planes and current bedding are not seen (see the description of a cutting through 20 feet of sand at Put Pan, Vryburg,

in Ann. Rep. Geol. Com. for 1906, pp. 68-71). The wind, working much more frequently than flood-water, obliterates bedding, and is not sufficiently constant to impose generally the strongly marked current bedding found in sections through sand dunes.

(44) Ann. Rep. Geol. Com. for 1907, p. 95; on Pepani, a farm south of Morokwen. Passarge records a probable local depth of 160 feet, "Suedafrika," p. 142.

(45) The Clanwilliam sand veld and the Zand Leegte are described in Ann. Rep. Geol. Com. for 1903, pp. 158-167.

(46) The large pan on Poortje and Meintjes Kraal, north of the Tanqua Karroo is in an abandoned course of the Bosch River (Ann. Rep. Geol. Com. for 1900, pp. 40-1) and is not strictly comparable to such a place as Haakschien Vley, but, like Verneuk Pan, it is a flat--cut part of a valley widened and devoid of vegetation. The bare patches of flat ground covered with mud in wet weather in the Great Karroo have ill-defined boundaries, though they are flooded with rain water for a few hours at a time They may well be pans in the making, but they lack the depression and well-defined borders of the northern pans, and bush stretches irregularly into them.

(47) The rainfall maps given by Mr. Charles Stewart in evidence before the Select Committee on Droughts in 1914, and printed in "Senate S.C. 2—1914" are most convenient maps showing average and seasonal rainfall within the Union A large collection of figures is given in Chapter II, "Climate and Meteorology," in Memoir No 4 of the Botanical Survey of South Africa, "A Guide to Botanical Survey Work," 1922, together with maps of average and seasonal rainfall. The older work of Buchan, "A Discussion of the Rainfall during the Ten Years, 1885-1894," Capetown, 1897, is very useful for the Cape Province. I may here acknowledge my indebtedness to Mr. Stewart for so freely giving me the benefit of his great store of information.

(48) A. Penck, "Die Morphologie der Wuesten," Geographische Zeitschrift, XV, 1909, p. 556.

(49) One of these pans, on the south-western part of Maraisdrift, has found an outlet to Riet Spruit, though the stream only partly drains the pan; this appears to be an instance of a pan which has overflowed its limits or has been breached by headward erosion of a stream and is in process of destruction through stream erosion. It holds water in its deeper part only after heavy rain.

(50) Passarge, "Die Kalahari," p. 648, and Chapter XXXVII; also in "Suedafrika."

(51) A. Penck, "Climatic Features of the Pleistocene Ice Age," Addresses and Papers read at the joint meeting of the British and S.A.A.A.S. in 1905, vol. II, pp. 1-9, also Geographical Journal, Feb., 1906, and in "Die Alpen in Eiszeitalter," pp. 1142-7.

(52) A. Penck, "The Shifting of the Climatic Belts," Scottish Geographical Magazine, June, 1914, pp. 281-283. Related questions are dealt with in Publication No. 192 of the Carnegie Institution, Washington, 1914, by Huntington and others, but I have not seen it; "The Climatic Factor, as Illustrated in Arid America." A review in Am. Journ. Sci. series IV, vol. 38, 1914, p. 563, shows that the work includes a discussion of the interpretation of terraces and the means of distinguishing those due to earth-movements from those dependent on change of climate, the bearing of the growth rings in the great Sequoias on the climate of the last 2,000 years and many other things connected with post-Pleistocene fluctuations of climate.

(53) R. Chudeau, "Les Changements de Climate du Sahara pendant le Quarternaire," C. R. Ac. Sci., March 7th, 1921, T. 172, p. 604.

(54) J. W. Gregory, "The Rift Valleys and Geology of East Africa," 1921, p. 149, and references there given.

(55) Passarge in "Die Kalahari," p. 657, refers to the lack of sand deserts in the Kalahari and suggests that the irregularly undulating sand veld in certain areas seen by him are the remains of old tracts of dunes formed during a hypothetical "Interpluvialzeit." The observations recorded in Ann. Rep. Geol. Com. for 1907, pp. 92-95, are in agreement with the old age of the present surface of the sand, for it was evident that "the existing long and short sand dunes have long been in their present positions."

(56) Instances are given in "Geology of Dam Construction," by A. L. du Toit, Proceedings of the S.A. Society of Civil Engineers, 1922, pp. 27-32, where he attributes the present entrenchment of the river beds in the alluvial deposits to the present greater rainfall following a period of aridity, which was preceded by a wet period. These instances are not quite of the same import as the partially filled-in kloofs of the Transvaal mentioned on a previous page, for the latter cannot be attributed to change by tilting or erosion, the distances involved being too short.

(57) The deposition of silt through the flattening of the grade of a river by erosion is well illustrated by rivers which leave soft rocks and pass over hard ones, such as the Hartebeest in Kenhardt, which, with its affluents the Zak and Olifant's Vley Rivers, passes from the soft Ecca and Dwyka beds over dolerite and gneiss; or the Dwyka and Gamka Rivers of the Karroo, which have cut plains on the comparatively soft Karroo beds and have covered them with alluvium behind the hard quartzites of the Cape System.

(58) The results of boring in the pan and their full discussion, together with a detailed account of the geology and economic aspects of the pan are contained in a Memoir, "The Pretoria Salt Pan, or Soda Caldera," by Dr. P. A. Wagner, which will be published shortly. A short study of the pan by that geologist is contained in his presidential address to the Geol. Soc. of S.A. printed in the Proceedings, vol. XX, for 1917, and he gave some further details in "Note on the Volcanic Origin of the Salt Pan, etc.," Trans. Geol. Soc. S.A., vol. XXIII, 1920, p. 52.

(59) Ann. Rep. Geol. Com. for 1907, pp. 107 and 109. Also, in Hay, Ann. Rep. Geol. Com. for 1906, p. 131.

(60) "A Note on Some Fossils from the Vaal River Gravels," by S. H. Haughton, Trans. Geol. Soc. S.A., vol. XXIV, 1921, pp. 11-16, where references to earlier finds are given; R. Broom, Annals of the S.A. Museum, vol. VII, 1909, pp. 279-282, and vol. XII, pp. 13-16.

(61) Ann. Rep. Geol. Com. for 1905, pp. 293-4.

(62) "Journal of Researches," London, 1839, pp. 99-104. W. J. Burchell, "Travels," vol. II, 1824, p. 207, "As far as I am able to judge, there is no region in any quarter of the world which can hold comparison with Southern Africa in number of large animals." Burchell also emphasized the weight of each animal, and gave it as his opinion that the average weight of the South African species would be found to be higher than that of species in other countries.

(63) E. H. L. Schwarz, "The Kalahari, or Thirst Land Redemption," p. 5. On the next page Prof. Schwarz says "it is incredible that the country (near Bloemfontein) could have supported such vast quantities of animals (to yield 6,000 head of game to a shooting party in one day) unless the climate and vegetation were very different from what they are to-day." I do not find it incredible, especially after seeing trek buck. In April, 1916, east of Karas Berg I passed a herd of springbok at a distance of some 800 yards; they subtended an angle of 45°, and I could not see a gap in the line nor the width of the herd in the line of sight; the buck overlapped. There were probably more than 6,000 buck in that herd, and the district is not a luxuriant one; one may easily travel 30 miles between waters, and farm houses are very far apart; the country near Bloemfontein is generally much better covered with grass, and we do not know whether arrangements were made for beating up game on the occasion of Prince Alfred's visit to Bain's Vley. Such herds as I saw near Karas Berg are doomed; they are incompatible with farming, and

they are more easily disposed of than locusts, a comparable pest from the farmer's point of view. If it were possible to compare the stock, large and small, now in South Africa, with the antelopes and other large animals 200 years ago, it is likely that the present stock would be the greater, because they are protected from the worst effects of drought by means of stored food and water. According to the figures in the 4th edition of the Union Year Book (p. 519) sheep have increased from an average of 35 to the square mile in 1904 to 63 in 1918, and allowing for devastation of war, which certainly affected the figures of 1904, and the effect of nurture, the increase is incompatible with increasing drought; the figures for cattle on p. 515 of that book give an increase of an average of 7·3 per square mile in 1904 to 12·6 in 1920.

(64) "The Agricultural Journal," "Farmer's Weekly," and other periodicals often publish correspondence on this subject, and the Report of the Select Committee on Droughts, etc. (Senate, S.C. 2—1914) brought out much evidence; of particular interest is that of Mr. Kanthack on pp. 49-55. The series of monthly records of rainfall from 40 places and the maps, part of Mr. Charles Stewart's evidence, are most valuable. Amongst the conclusions of the Committee the important points for our purpose are (1) that there has been no definite diminution of rainfall during historic times; (2) that there is considerable variation, which increases in proportion to distance from the coast; (3) soil erosion has been greatly increased by human activities; and (4) this erosion is responsible for the desiccation of certain parts of the country and, if unchecked, will render those parts practically useless to man.

(65) E. N. Marais, "Notes on Some Effects of Extreme Droughts in Waterberg," Agricultural Journal of South Africa, VII, 1914, pp. 164-170.

(66) F. Jaeger and L. Waibel, "Beitraege zur Landeskunde von Suedwestafrika," Mitt. aus d. Deutsch, Schutzgebieten, Erganzungsheft, 1920, No. 14, pp. 50-51. This and the second volume (Erganzungheft No. 15) contain very valuable accounts of the physical geography of the country, more especially of the northern districts. The question of change of climate is specially discussed on pp. 50-55, and the conclusion is reached that progressive drying-out of South Africa is not proved, and that it is not probable; that the ground-water level is subject to important fluctuations extending through periods to be measured in years and decades. He quotes a missionary resident in Amboland during 43 years to the effect that there has been no general decrease in the waters there during that period, only fluctuations.

(67) The aims of the Survey are clearly stated by Dr. Pole-Evans in the Introduction to Memoir No. 4, "A Guide to Botanical Survey Work," 1922; the kind of information desired for comparison of identical areas at long intervals is described in Chapter V, by Dr. J. W. Bews.

(68) J. S. Henkel, Report of the 14th Annual Meeting of the S.A.A.A.S. 1916, pp. 179-186. He points out the importance of forest progress to the conservation of water and soil, and the influence of certain plants in aiding the extension of forest by resisting the spread of fire.

(69) T. R. Sim, "Causes leading towards progressive Evolution of the Flora of South Africa," South African Journal of Science, 1920, pp. 51-64. Mr. T. G. Trevor writes: "In the south-western Orange Free State the nature of the vegetation has visibly altered in my memory. The grass in the conquered territory and about Edenburg has distinctly altered; in the former district it was previously close growing, it is now tuft. In the latter bushes are replacing grass." During the meeting of the Association this year Prof. Bews told me that he considers the forest vegetation of the east side of the Drakensberg to be an essentially progressive one. See his paper, "The South-East African Flora," etc., Annals of Botany, XXXVI, April, 1922.

(70) "Memorie, houdende de consideratien en advys van het Departement tot de Indische Zaaken, omtrend den Voet en Wyze, waarop de Regeering van de Caap de Goede Hoop, eventuell zal behooren to woorden engericht." Published, with an English translation, by the Van Riebeek

Society, Capetown, 1920. The description of the northern border is on pp. 41-2 of the Dutch transcription and on p. 195 of the translation. On pp. 43 and 197 it is incidentally mentioned that the journey by wagon from Graaff Reinet to the Cape could only be undertaken at certain seasons, a circumstance referred to by travellers who wrote earlier accounts of these regions.

(71) George Thompson, "Travels and Adventures in Southern Africa," London, 1827, Chapter II, especially pp. 334-343. The "drought of the climate (in Albany) is emphasized. Thompson visited the Fish River in 1823 and wrote of it: "The dreary and desolate aspect of the country up the Fish River, from Grahamstown to Roode-Wall has been frequently noted by former travellers, and seems indeed to be scarcely susceptible in any respect of improvement. The farms 'few and far between' are mere vee-platzen or cattle-places, without in general the comfort of a garden, or the means of cultivating a single blade of corn." Thompson's book has good accounts of the north-west and Bechuanaland.

(72) The diary is reprinted in "Reizen in Zuid-Afrika in de Hollandse Tijd," vol. I, pp. 139-211, 's-gravenhage, 1916. (Linschoten Society's publication). This is easier of access than Valentyn's book or the translation by Buchenroder in the "South African Quarterly Journal," 1829-32. The latter appears to be incomplete.

(73) Le Vaillant, "Voyage de F. Le Vaillant dans l'interieur de l'Afrique," Paris, An. VI (1798), vol. II, p. 353. He was urged to hasten across the Karroo in February on his way S.S.W. from Sneeuwberg before the heat had dried the little stagnant water which might be found there; he failed to find water in the Traka.

A. Sparrman, "A Voyage to the Cape of Good Hope, etc." London, 1785. He found very little water at Commadagga in December, vol. II, p. 90.

Paterson, "A Narrative of Four Journeys into the Country of the Hottentots and Caffraria in 1777-9," London, 1789.

C. P. Thunberg, "Travels in Europe, Africa and Asia," London, 1795, 4 vols. Vol. II, p. 101, the "Karroo cannot be inhabited; and scarcely any animals reside there, except for a short time in or immediately after the rainy season, when a little salt water is found here and there in some of the hollow places." Also p. 204.

J. Barrow, "Travels into the Interior of Southern Africa," 2nd edition, London, 1806.

Adam Tas's Diary (edited by L. Fouché, with a translation by A. C. Paterson, London, 1914) has many notes on the weather at Stellenbosch from June, 1705, to February, 1706. Of December 25th, 1705, he says: "I doubt if it ever happened before that in the heart of summer there had been so fearsomes a rain," p. 87. Residents at the Cape will recall such instances, one was in 1900.

Useful indications as to where to look for notes on climate in South Africa will be found in J. G. Gamble's catalogue of books and papers on climate, etc., in Trans. S.A. Phil. Soc. vol. III, pp. 158-196.

(74) J. Barrow, op. cit., vol. I, p. 54.

(75) J. Barrow, op. cit., p. 289. The rain fell in Camdeboo and Sneeuwberg. He does not mention rain further west than Camdeboo, and he may have thought that some of the area was in the catchment of the Kariega, but most of the Camdeboo rain and all from the southern flank of Sneeuwberg would feed the Sundays River.

(76) W. J. Burchell, "Travels in the Interior of Southern Africa," vol. I, 1822, vol. II, 1824. Vol. I, chapter XI. In vol. II, p. 299, there is an account of Kuruman spring, the largest he had seen in South Africa. Of the Kuruman River "it is said that in the wet season it is joined by the Mosowa; and that in those years when an unusual quantity of rain has fallen, the united streams find their way to the Gariep." "Unlike other rivers, the Kuruman is largest at its source, and rises from the earth a full and broad stream, which, by the combined powers of evaporation by the sun and of absorption by the sandy soil, is gradually lessened

as it flows on; till at last, after a course of a few days' journey, it is lost in the sands and entirely disappears." In 1907 the open water disappeared near Tsenin, about 40 miles from Kuruman, but the water was being used for irrigation at many places on the way. A very good description of the conditions in 1907 will be found in a paper, "Bechuanaland from the Irrigation Standpoint," by Mr. F. E. Kanthack, in the Agricultural Journal, Capetown, for the last four months of 1909. This paper contains many interesting observations on subjects other than the general water resources, such as the effect of the nature of the soil on run-off, and a critical account of the popular impressions of the behaviour of the Molopo.

(77) Mr. T. G. Trevor, who has a wider personal experience of the Transvaal, extending over 30 years, than any other friend of mine, is sure of this general decrease in water. He writes: "I have gone into the matter very carefully and am satisfied that the loss of available water has gone on not only in the inhabited districts but everywhere, and is not entirely due to surface erosion, as it is relatively as well marked in wilderness and uninhabited districts as in the occupied areas."

Mr. W. H. Gilfillan, a former Surveyor General in the Transvaal, tells me that the Waterberg, which he has known since 1886, has not, in his opinion, had its water resources diminished during that period, but that drainage and cuttings to fountains have lowered the water level at places.

The practice of irrigation must have altered the normal conditions of many rivers in the country by withdrawing water from the upper valleys systematically. The use at Pretoria of some 5 million gallons a day from the springs which once fed Aapies River is another instance of the same kind.

A description of the Sand River, O.F.S., by Zeyher, the botanist, is of interest: "The Sand River which we found exceedingly difficult in fording, on account of its steep banks and the great masses of shifting sand. . . . Although there was only a small stream of water running in its channel, the high and abruptly steep banks of that river showed evidently that it had been a formidable gulf and a barrier." Hooker's London Journal of Botany, vol. VII, p. 327, and on p. 328, "The channel of the Falsrivier lies more than 100 feet deep, between banks." It is hardly necessary to note that deep channels do not imply that permanently deep rivers occupied them at any period. I have to thank Dr. Schönland for telling me of Zeyher's narrative, and Dr. Haughton for looking it up and abstracting paragraphs in Capetown.

Arbrousset, "Relation d'un Voyage au Nord-Est de la Colonie du Cap," etc., Paris, 1842, p. 149, writing of Basutoland in 1836, says: "The Orange River is, like the Caledon, subject to periodical floods which happen three or four times between the end of November and the middle of April, the first flood usually lasting ten or twelve days, the two or three others five or six weeks."

(78) Passarge, "Suedafrika," p. 153. Chapters XV and XVI of that book have an excellent summary of the topography of the region and a discussion of change of climate; see also "Die Kalahari," p. 490.

(79) E. H. L. Schwarz, "The Kalahari and Ovamboland," Nature, May 16th, 1920. The sudden opening of the gorge is entirely at variance with the description of the bevelling and of the increasing length of the tributaries and their adjustment to the water level in the gorge written by Mr. G. W. Lamplugh; Geol. Mag., Dec., 1905; Rep. Brit. Assoc., 1905; Geographical Journal, Feb. and March, 1908.

(80) Griffith Taylor, "Climatic Cycles and Evolution," The Geographic Review, Dec., 1919.

THE ROLE OF ASTRONOMY IN THE DEVELOPMENT OF SCIENCE.

BY

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Presidential Address to Section A, delivered July 10, 1922.

There is a difficulty, which has almost always been recognised by Sectional Presidents, in giving an address dealing with all the subjects considered by each section. In the present case I must confess that matters relating to engineering, architecture and irrigation are quite unknown to me.

To the president of a section two ways are open, either to give an address on a special subject which he may develop, or to make a general and vague exposition of the subjects dealt with by that section.

In the first case his address cannot be distinguished from the papers that can be read by any member, and, to many members of the section a work of that kind cannot be interesting; in the second case he can deal with subjects which will interest everyone, but, as he has to touch lightly on all those subjects, he is liable to become tiresome.

I have decided to take the second way. Nothing of what I am going to say is unknown to the members of this section, but I promise to be short in my address in order to diminish the uninteresting.

. . . .

I am going to endeavour to demonstrate what Science owes to astronomy. I shall not mention those sciences which depend directly on astronomical observations, such as geodesy, geography, etc. These sciences could well be considered as chapters of astronomy. As astronomy is the science which studies the movement, form, chemical and physical constitutions of celestial bodies, those who study these problems of the earth, which is also a celestial body, have an objective which could be included in astronomy.

But my aim is not to put a label on those sciences to say afterwards that astronomy is a fundamental one. I truly believe that astronomy is a fundamental science, but from a different point of view: I consider it the mother of all other sciences. But the influence of astronomy upon the other sciences is, in general, very remote. It is only at the end of a long time that a conquest of astronomy will manifest itself in the progress of other sciences. In this manner the primary origin of the great conquests is forgotten. When a notable progress in science arises, few people remember that it is due very often to the investigation of the astronomers.

It is in consequence of this that some people consider astronomy as an almost useless science which only serves to amuse the minds of the persons who devote themselves to it. Notable names, such as that of the philosopher Auguste Comte and of Prof. Bouasse, have endorsed this opinion. I want to show what is false in this appreciation.

Although its utility is not very apparent, astronomy is the most popular of sciences. It is due to this fact that it owes the protection it receives from governments and private persons in all civilised countries. Without that popularity it would not be easy to obtain from governments and private persons the large sums necessary for the erection and keeping of observatories.

Where did that popularity come from? It would be giving a metaphysical explanation of the case, to say that it is due to an unconscious feeling of the utility of astronomy. I believe that the true motive in this case is the flattering of the most vehement wishes of mankind by astronomy. For ages, at least since the time we have possessed historical documents, two objectives have troubled mankind: to associate himself with other beings and to guess the future.

The first was obtained by the building up of social organisation which for centuries has successively improved itself. But of all the classes of inhabitants of the earth, only men entered in that organisation. The other creatures, owing to their inferior intellectual condition, had to remain subjected to a simple situation of dependence.

There are some animals, however, such as the ants, which seem to reveal a great intellectual development and show a certain amount of knowledge that we attribute, perhaps by vanity, to an unconscious instinct. It is a known fact that swallows travel between Europe and America over the vastness of the Atlantic Ocean, knowing where they are going, and returning to the same place. The prescience that some animals have with regard to the changes of weather, sometimes long in advance, is also a fact that cannot be contested. These cases cannot be explained by the teaching of experience, because the life of these animals is too short; we cannot attribute it to a transmission from one individual to another individual, because the language of animals is simple and seems to translate only sentiments and not ideas. These cases can only be explained by the animal's instinct, which is equivalent to explaining nothing.

But even if there were other animals with the same intelligence as that of men, the socialisation of the species would be impossible; we should not understand their language, nor would they understand ours so perfectly that it would be possible to have long communications. So, man had to circumscribe his wish of socialisation to his equal. But one day it was learned that in space there were planets analogous to the earth. The idea that in them could be found inhabitants with whom we may make ourselves understood attracted to astronomy the sympathies of the people.

I do not wish to discuss here if that idea may some day come true. Animated life is a mere and short incident in the evolution of a celestial body; and of the living beings there may be as great a variety as on the earth, where the simple bacteria are as real inhabitants as men are. I mention this case only because it seems to me that it is the one which has attracted the attention of the people to astronomy.

The other wish of mankind, the predicting of the future, also in a certain manner was flattered by astronomy. I do not refer to the superstition of the olden days, which even now is not thoroughly dissolved, of the influence of the planets upon our lives. I only refer to the accuracy with which the methods of astronomy allow us to know, centuries in advance, the positions of celestial bodies. It was always a case which pleased the people, the knowing that on such a day and at such an hour there would be an eclipse of the sun in this or other circumstances.

It is thanks to this prestige that astronomy has been able to progress and thanks to its progress that the other sciences have been able to advance.

In three different ways has astronomy helped the other sciences: firstly, giving them the certainty that Nature is ruled by laws; that in the world reign harmony and simplicity; secondly, giving them the models and putting successive problems; and, thirdly, assisting them with the help of observations.

. . . .

The contemporaries of Tycho Brahe might have asked what utility his extended observations could have. Perhaps Tycho himself did not recognise in them a utility other than that of delighting his mind. But we know that those observations allowed Kepler to enunciate his well-known laws; and these laws revealed to mankind, that in the apparently arbitrary and complicated motions of the planets, there is something of the common and simple.

From the laws of Kepler, Newton deduced his celebrated law of gravitation, which can be considered as a *résumé* or condensation of them. But the field of its application was extended. The motion of the comets, which Kepler despised, because he believed they were simple meteors, showed that they obeyed the same law. The moon and the bodies with which we deal here, at the earth's surface, all obey Newton's law. Later on, it was ascertained that the components of double stars also obey this law.

The influence of Newton's law upon the human mind was enormous, and this influence was exerted in three ways. Firstly, a law that prevails through all known space revealed to mankind that Nature is everywhere the same, disciplined and simple in its elementary processes. There was found in Nature an unexpected harmony which gave man the courage to enter deliberately on the search for the secrets of Nature, because he knew from that time such secrets were not impenetrable.

Newton was not the inventor of the steam engine or wireless telegraphy, but he prepared the human mind so that others were able to do that.

Another way by which the law of gravitation exerted its influence upon the development of science was in stating actions at a distance. This meant a revolution in the views of those times. Until then, only actions of contact, such as pressures, tractions, etc., were known. Due to the views of Newton, a dualism appeared: actions of contact and actions at a distance.

The physicist does not like dualisms. But it was not easy to reject the hypothesis of Newton, for his law not only gave a fair account of the observed movements, it also harmonised with the idea of a free space, homogeneous and isotropic, because the statement of a variation of the action inversely proportional to the square of the distance showed that gravitation spreads uniformly in all directions and is uniformly distributed upon the surface of a sphere, its total intensity being constant whatever may be the radius of the sphere.

In order to avoid the dualism, physicists were inclined to regard actions of contact as actions at a distance (distance very minute, of course). Bodies were regarded as formed by very minute particles which exercised between themselves actions at a distance.

This way of regarding the constitution of matter (which later was to give chemists the idea of the atomic theory) caused physico-mathematics to be born; physico-mathematics is, as the "Mécanique Céleste," a daughter of the law of gravitation.

Later on, physico-mathematics evolved and is nowadays a science very different from the "Mécanique Céleste." It should not be forgotten, however, that, if the principle of gravitation is not at present directly applied to the mathematical treatment of physical phenomena, other principles are applied, some of which are derived from it, in the former phases of this branch of science.

Physics and chemistry have nowadays a tendency to be merged in a single science through the present ideas on the constitution of the atom, of which you heard a good explanation, a year ago at Durban, by one of the pioneers of the new theory. Dr. Moir. The time seems not far distant when chemical phenomena may be treated mathematically, as are physical ones, through the movements of electrons.

It is already believed that electrons go round the nucleus of their atom and it was astronomy that gave the model for those movements, as it is assumed that they keep a planetary motion. This assumption gives a fair account of some facts as, for example, the features of some spectra.

Thus, it was the law of gravitation, originally due to the skilful observations of Tycho Brahe, that gave the directive and strongest impulses to scientific investigations.

Before going further, let me open a parenthesis:

Is that attraction, that gravitation, that action at a distance stated by Newton's law, real? This question does not interest the physicist if there is no fact that may contradict the existence of such an action. For the metaphysicist, the question is a fundamental one. The aim of Science is to know the Truth. For knowing it, man has at his disposal experience, observation and ratiocination.

The physicist, confronted by phenomena, tries to explain them by the hypothesis that will bind the greatest number of them. The metaphysicist searches for something more: he searches for the *nomena*, *i.e.*, the transcendental cause of *phenomena*.

Let me give you an example showing the difference between the aims of the physicist and the metaphysicist:

I let a stone fall; this may be explained in two ways, namely:

(a) The stone has a tendency to approach the soil;

(b) The soil attracts the stone.

To the physicist the two ways are equivalent, so long as he knows no other phenomena; to the metaphysicist they are not only different, but contradictory, because the former ascribes the cause of the fall to the stone, while the second one ascribes it to the soil.

When choosing between the two ways, the physicist investigates which of them may include more phenomena, *i.e.*, which is more general. What interests him is the generality, not the reality.

But what is reality? Our knowledge of facts is given us by our senses. Each of us sees the world in a manner in which it is not possible to know if it is the same manner in which it is seen by another. The world may have for each of us an aspect thoroughly different from that which it has for another. Which of these aspects is the true one?

There are only three possible answers to this question: all, none, only one. To each of them corresponds a meaning of the word *true*.

The first is the answer given by the physicist. He is not interested in metaphysical speculations over the reality of the world. He knows it only by the impressions which the objects cause upon his mind; for him, the external world exists only within his conscience.

The law of gravitation is only an hypothesis giving an explanation of a certain class of movements. So long as one of these movements does not contradict it, the physicist does not doubt it. As you know, the ever-growing perfection of apparatus caused some doubts to arise, but let me put this matter aside for the moment. As to the reality of gravitation, we can only state that the movement of a body is influenced by the vicinity of others. This influence may be explained both by a direct action

or by an alteration of the physical properties of space. The law of Newton explains it by a direct action.

This law is a consequence of the principles of mechanics of Galileo and Newton himself. The principle of inertia introduces the notion of force in all movements that are not uniform and rectilinear. So it is necessary to assume the existence of a force directing celestial bodies.

By Ptolemy the movements of the celestial bodies were explained by a network of circular orbits, because circumference was regarded as the *noblest* and *most perfect* of lines and was, therefore, the way in which a free body moved.

It may be said that Ptolemy also created a principle of inertia which differs from the principle of Galileo as being *circular* instead of *rectilinear.*

In the law of Newton, force appears as explaining *curvature.* If mechanics were based on the principle of Ptolemy instead of the principle of Galileo, force would appear as explaining the *changes* of curvature.

We would have then a law of the planetary movements different from Newton's law, but it is easy to see that such a law would be more complicated.

As to that law we might say, as we say about Newton's law, that it is not possible to deny the influence of a body on the movement of another; but how is that influence exerted? *Apparently*, as the law states; *really*, we do not know.

Indeed, we never measure forces; what we observe are their consequences, *i.e.*, acceleration or equilibrium, in all cases, movement. The principles of mechanics give us the standard for this measurement. We measure movements by comparison with a standard movement we name rectilinear and uniform, as a merchant measures the length of a piece of cloth by comparing it with the length of a bar he names metre or yard.

The study of mechanics might be made without the introduction of the notion of force. This notion is, however, useful because it facilitates that study and is necessary when we deal with changes of energy, that is, when we have to relate heat, electricity, etc., to movement.

When apparatus and methods of observation were improved, it was recognised that the law of Newton did not altogether explain the observed motions. It was the planet Uranus which presented the greatest irregularities. Nobody, however, doubted the accuracy of the law, and these irregularities were ascribed to some unknown body. Acting on this assumption, Adams and Leverrier discovered, by calculation, the planet Neptune.

But other bodies still present irregularities. Outstanding examples are the Moon and Mercury. In explanation of these irregularities, it was necessary to put aside the accuracy of the law, and explanations are many and varied. One of them is to alter the exponent -2 of the fundamental law, which changes

our views about a propagation by spherical shells. Another one is the assumption, contrary to the conclusion of Laplace, of a non-instantaneous propagation of gravitation. Another one is to assume that gravitation is refracted through gravitic masses, as light through refracting media. Yet another one is an alteration in the principles of mechanics as proposed by the general theory of relativity, of which some of you may have heard a good explanation from Professor Dalton.

But these explanations have not the generality of Newton's law: the alteration of the exponent also strongly alters the results already confirmed by observation for other bodies; the refraction is only to be applied to the motion of the Moon. The relativity theory accounts sufficiently well for the irregularity of Mercury, is approximate as to a small irregularity of Mars, but does not explain the irregularity of the Moon. Notwithstanding, it is this last theory which has the greatest likelihood of superseding the law of Newton.

In short, astronomical observations created the law of Newton, and, with it, gave the first and strongest impulse to scientific investigation. Later on, the same observations, but improved, caused a doubt to arise as to the accuracy of the law and gave origin to new investigations. Man is nowadays weighing his knowledge, trying to separate what is hypothesis from what is real, in order to reinforce the foundations of Science.

. . . .

But not only in the development of general Science has astronomy assisted civilisation. Some special branches of science have been strongly developed by astronomical observations.

Excepting few data about the Sun which are given us by its calorific, magnetic and electric radiations, all we know about celestial bodies, such as movement, masses, physical and chemical constitutions, is given us by the light they emit. So, optics owes a great part of its development to astronomy.

It was by his observation of the eclipses of the satellites of Jupiter that Roemer discovered in 1676 that light travels with a finite velocity. However strange this statement may appear, it will be recognised that this discovery was the first step towards the invention of wireless telegraphy. By that time, Sir Isaac Newton was working up the corpuscular or emission theory of light. The discovery of Roemer—light moving as a material body—forced him to modify his former views in order that the principles of mechanics could be applied to light. Huygens, however did not agree with Newton's views and, in 1678, presented his wave theory of light. Both theories gave a bad account of some luminous phenomena; so that it was easy to contradict them.

The wave theory was supported by the similarity of sonorous and luminous phenomena. Curiously enough, Newton, who was the creator of the wave theory of sound, did not wish to apply the same principles to light. So tenaciously did he defend his

views and so high was his prestige among physicists, that only a very few agreed with Huygens. The tenacity and prestige of Newton weighed heavily upon physical optics, during nearly two centuries, retarding the development of this branch of Science.

It was only in 1819 that a French engineer, Fresnel, departing from routine, established his wave theory. But Fresnel carried his audacity farther. Instead of, like Huygens, assuming longitudinal displacements, he did not hesitate to assume transversal displacements of a medium (the ether) which he first defined as an imponderable and perfect fluid.

In solid bodies the cohesion of molecules allows us to explain how the movement of a particle in a given direction can draw the particles in a perpendicular direction, giving rise to transversal propagation; in a perfect fluid, such cohesion does not exist at all, nor does the transversal propagation exist. Furthermore, in solid bodies the displacements propagate in all directions, giving rise to both longitudinal and transversal propagations; in perfect fluids there is only the longitudinal one. In both cases, the longitudinal displacements always exist.

Fresnel, however, did not assume for the ether the existence of such displacements. The great mathematician, Monge, did not hesitate to say that Fresnel's theory was an "absurdity of mechanics." But, if this theory was not in agreement with common sense and the results of experiments made in vibrating solids and fluids, it explained very fairly all known optical phenomena. So physicists were forced to agree with Fresnel's views and were content with assuming for the ether those properties which could keep common sense untouched.

In order to explain the existence of transversal displacements, ether was regarded as an elastic solid. In order to explain the non-existence of longitudinal ones, two ways could be followed: to assume an instantaneous propagation or an infinitely slow one. In the former way, ether was to be regarded as incompressible; in the second one, as having a negative coefficient of elasticity, or, say, a tendency to contract.

Evidently, the theory would not resist so many phantasies, had it not the strong support of numerous and varied experiments of which it gives a sound explanation.

Later on, Maxwell, comparing data measured in electrostátic and electromagnetic units, arrived at the conclusion that electromagnetic disturbances propagate with a velocity equal to the ratio of those units, which was found to be equal to the light velocity in vacuo. This was the basis of his theory—the electromagnetic theory of light—in the development of which he predicted the existence of the waves which have taken the name of the man who, for the first time, produced them in the laboratory—Hertz. It was, therefore, the knowledge of the velocity of light, discovered by the astronomical observations of Roemer, which allowed this remarkable advance of science and civilisation.

But optics owes yet some other developments to astronomy.

It was, indeed, optics with its spectroscopic methods which assisted astronomers in the search for the physical and chemical constitutions of celestial bodies; but, when stellar spectra were compared with terrestrial ones, some differences appeared, the origin of which it became necessary to ascertain. This gave physicists some important data on the effect of pressure and temperature on the features of spectra.

In terrestrial laboratories, it is not possible to get such high temperatures and pressures as we find in the stars. Stars are the great laboratories from which the astronomer takes the observations that are useful to the physicist.

The determination of radial velocities of the stars, which seems to be a problem that interests only the astronomer, constitutes a strong aid to the physicist, because it means strong experimental support of the wave theories of light. Had the astronomer not been able to detect such velocities by the spectroscopic method, such an experimental confirmation would not have been obtained, because on earth we have not velocities sufficiently great to render the phenomenon measurable.

Not only in the restricted field of optics can astronomy assist Science. As you know, we have nowadays a fair knowledge of the chemical constitution of the stars, but this constitution differs according to the class of each star.

There are elements that are only observed in some states of stellar evolution. It is for astronomy to say if there are elements that actually exist, but are not observable, or if these elements have already disappeared or will appear later, by transformation of others, as may be the way of stellar evolution. As to stellar evolution, our knowledge is somewhat hypothetical.

The astronomer among stars has been compared to the traveller among the trees in a forest, who, although he does not see the trees growing, can, however, know their evolution as he sees them in all their ages. The comparison is not a very good one, because the traveller knows, by former experience, that trees born small, grow up and reproduce themselves. The astronomer cannot have a similar experience about the stars, because life is too short.

I will end this address with the most recent instance of the assistance of astronomy to physics.

The existence of a medium, assumed in both the light theories of Fresnel and of Maxwell (although with different properties), gave physicists the wish to determine the velocity of the earth relative to it.

The discovery of the aberration of light by the astronomical observations of Bradley in 1728 showed that such a medium is not drawn by the earth in its motion.

Due to similarity of luminous and sonorous phenomena and theories, physicists believed it would be possible to detect an

" ether-wind " as it is possible to measure the velocity of the wind: measuring the velocity of light in different directions.

The result was a negative one, and this showed a fundamental difference between sonorous and luminous phenomena.

There is, however, an important difference in the methods of measuring such velocities. The velocity of light is measured by *exclusively optical* devices, but that of sound is *not* measured by an *exclusively acoustic* device. So long as it is not possible to measure the velocity of sound by an exclusively acoustic method (*i.e.*, measuring time and lengths by ear, as, in the case of light, they are measured by the eye), we have not the full right to affirm the existence of that fundamental difference.

The conflict between optics and mechanics which arose from the constancy of the velocity of light in vacuo, can be settled by the theory of Einstein, who ascribes it to our optical methods of measuring time and distance.

As you know, the chief confirmation of Einstein's views depends on astronomical observations.

Therefore, on the road of its development, physics arrives at bifurcation; it waits that astronomy may say which of the two ways it shall follow.

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I have pleasure in thanking Mr. R. H. Fox for aid in translating this address from Portuguese into English.

THE INFLUENCE OF MINERAL DEPOSITS ON THE DEVELOPMENT OF A YOUNG COUNTRY.

BY

E. T. Mellor, D.Sc., F.G.S., F.R.S.S.Af., M.I.M.M.

Presidential Address to Section B, delivered July 11, 1922.

To find the preparation of a presidential address a much more difficult task than the writing of an ordinary scientific paper on a well-defined special subject is probably a common experience.

A very usual course in addresses of this kind appears to be to make a general review of the subject in which one is particularly interested, and perhaps to forecast future developments, or, in the case of a section like this, participated in by the followers of various allied branches of science, to consider the relationships of such branches to one another and to science in general. Previous presidents of "Section B" have, however, quite recently covered both these fields.

Progress in many branches of science during the past few chaotic years would be a somewhat difficult thing to gauge, although I am inclined myself to place a very high value on the results of the work done by scientific men during the recent war, along the many new channels into which their activities were forced by the stress of exceptional circumstances, in a way that nothing but a great war could have brought about. When these results can be fully worked out in all their developments, I believe we shall find that greater progress has been made as a consequence of those special conditions than we can at present realize.

Some of the more usual lines on which addresses of this kind are written, being, therefore, excluded, I have chosen as my subject one which I hope may be found of fairly general interest, while at the same time one with which my own particular line of scientific work has brought me into continual contact in the past few years, during which I have been more especially associated with the economic applications of geology.

Residing in the midst of one of the largest mining fields in the world, and, at the same time, being brought continually into contact with mining enterprises of every grade of development and importance, from the earliest stages of prospecting a potential future mine to a full-grown mining field like the Witwatersrand, the relationship of the mineral deposits of a country to the community as a whole, and the great variety of conditions under which mining enterprises take their origin and are carried to fruition, has, in my own experience, proved quite as full of interest as the more tranquil pursuit of purely scientific lines of investigation.

This is, perhaps, all the more true because to the study of interesting geological problems there is frequently added that touch of human interest, the absence of which so often makes itself felt to the geologist who is frequently called upon to carry on investigations in remoter districts of the country.

In dealing, therefore, with the development of a mining field, and some of the relationships of the mineral industry generally to the life and progress of a young country, I hope to have chosen a subject which will not be without interest both for geologists and for those interested in the many other allied branches of scientific work who come at some time or another into connection with the development of the mineral resources of the country.

If it should appear that, in choosing my examples, undue prominence has been given to certain mining fields, my excuse must be that, by dealing with subjects with which one is most familiar, one is the more likely to bring out some point of view which may be of interest to others. Both from a purely geological and from an economic point of view, the Witwatersrand gold field has proved by far the most interesting mineral occurrence with which I have come into contact in the course of many years of geological work, and it furnishes, at the same time, a most useful example of the extent to which a mineral deposit may influence the general development of a young country. It may be of interest to review the stages by which it has attained its present position, in what way it has been assisted by or has stimulated research in various branches of science, and to inquire as to what extent we may look to other possible mineral fields to provide additional avenues of industry in the future.

Situated almost in the centre of Southern Africa, we have in the Witwatersrand one of the greatest and most productive mining fields in the world, certainly by far the most productive gold field, whether we measure it by actual current production or by the aggregate of the gold hitherto won.

For a gold field, it has already attained a fairly long life, especially when we consider the progressive increase in its output, until the change of conditions brought about by the late war affected it in common with so many other still older and more firmly established industries, and when we also take into account that it promises to continue to be the most important gold field in the world for yet a long time to come.

The development of the Rand may be said to have been comparatively slow, as gold fields go, and a very large proportion of those living in its vicinity found it already an established fact when they first came to the district. Partly on this account, perhaps, and partly because of the widely ramifying nature of its influence, the important bearing of such a mining field on the development of a young country like South Africa is not generally appreciated even by those who dwell within easy reach of the field itself, while by the inhabitants of more distant parts of the

country it is still less understood. The Witwatersrand is usually looked upon by such people as an extraordinary place where almost anything can happen, and which frequently exerts a disturbing influence on an otherwise peaceful country.

Before making more special reference to the Rand, it may be instructive to glance for a moment at one or two simpler examples.

The influence of a profitable mineral deposit in opening up a new country comes out perhaps in the most striking manner when the occurrence is comparatively small and situated in a district which, either by its inhospitable nature or its remote situation, might otherwise have remained practically untouched for an indefinite number of years. Two instances, which have come especially under my notice, have always seemed to me to afford most stimulating food for thought, and it may be interesting to refer briefly to them to illustrate the point I wish to make with regard to more important deposits.

One of the examples which I have in mind is the Tsumeb Mine in South-West Africa. The mineral deposit mined at Tsumeb consists mainly of ores of copper, lead and silver, and is one of those remarkably concentrated mineral occurrences which appear entirely disproportionate to the effects which their discovery and exploitation bring in their train. The whole outcrop of the ore body could be covered by a moderately sized public building, and its cross section continues to be of much the same dimensions in depth. If we attempted to indicate such an ore body to scale on an ordinary wall map of Africa, it would have to be represented by an almost invisible dot, or, taking its depth also into account, by a pin prick not much deeper than the thickness of the paper on which the map is printed.

Yet this deposit, which bears such an absurdly small proportion to the area of the province in which it lies, and which, without being worked for much more than two or three hundred feet in depth, was the means of building, equipping, and, what is also satisfactory, paying for, a railway from the coast to the mine, some 350 miles in length. The mine then continued for some years to pay unusually large returns to its shareholders, and still remains a very productive concern. A small township has developed around it, and constitutes a centre of activity for a considerable district. Few things I have seen have impressed me so forcibly with the potentialities of a mineral deposit in bringing a railway into country otherwise not particularly attractive, than the experience, after the long railway journey from the coast up to the Tsumeb Mine, of finding at the end of that stretch of rails, what at first sight would appear to be so insignificant a body of mineral. And perhaps no less remarkable than the length of such communications is the speed with which they may be established when a rich mineral deposit is the objective in sight.

The second and similar example I have in mind is the remarkable deposit of ores of lead and zinc at Broken Hill in

Northern Rhodesia. In this case the mine did not build a railway, but it partially determined the course of the main Cape to Cairo line, and for a long time formed its northern terminus. It is still a most striking experience, after travelling for twenty-four hours from Victoria Falls, through country showing so little alteration at the hands of man, suddenly in the midst of the wilderness to come upon an active and busy mine like Broken Hill, and a township which, though small, is larger than any other for hundreds of miles in any direction.

Yet the main ore body, which is the cause of all this activity and development, scarcely exceeds 300 feet in its longest known diameter, and would form even a less conspicuous spot on the map than Tsumeb. It consists, however, of an unusually compact and solid mass of rich lead ore, surrounded by a shell of ores of zinc, almost free from anything in the way of gangue or other extraneous material, so that we have within what appears a very small compass a highly important mineral deposit. This deposit originally formed a prominent and conspicuous kopje, rising abruptly above the surrounding flat country, which attracted the attention even of primitive man, for you will recall that it was from a cave which could be entered from the surface of the kopje that there was recently obtained the remarkable human skull which has aroused so much interest among anthropologists in Europe. It was, however, only in comparatively recent years that this haunt of primitive man was recognised as the outcrop of an important mineral deposit.

I have chosen the two examples to which I have referred because they clearly indicate the driving power which even comparatively small bodies of mineral may exert on the development of, at least, that first necessity in opening up a young country—the provision of transport facilities—and I have chosen them more especially because in both cases their effect has been quite clear and is not obscured by the influence of other factors, such as must be taken into consideration in the case of a mining field of quite another order of magnitude like the Witwatersrand. In such a case the longer period over which the development of the field has been spread, and its situation in the neighbourhood of other centres of activity of various kinds, exhibiting a parallel growth, render it less easy to recognise clearly the specific influence exerted by the gold field itself. In the direction to which I have drawn attention in connection with my two former examples, however, that of transport facilities, it is only necessary to glance at a railway map of South Africa to realize to what an extent the railway system of a very large part of the Union has been influenced by the gold field of the Rand. We see in it not simply the objective of a single line of railway, but of many lines —a ganglion in the transport system, so to speak. I believe it would be interesting and illuminative if the railway administration would publish returns in such a way as to show the actual earnings of the various main lines and branches in the South African railway system. It is not likely, for many reasons, that this will ever be done, but I do not fear contradiction when I say that the

returns on traffic directly or indirectly connected with the mining field of the Rand have furnished the largest portion of the means of building up our system of railways and harbours, and play a still more important part in maintaining them.

In support of these statements, and to emphasise also the great importance of the part which can be played by a big mining field in the development and general prosperity of a young country, it is necessary occasionally to put the matter into definite figures. I recently had occasion to refer to this matter in a broad way in another connection, and I will ask your indulgence while I quote from the notes I then put together:—

"The Witwatersrand output of gold for 1920 valued at nearly 44½ million pounds, amounting to 49.9 per cent. of the world's production, and with an aggregate output, up to 1920, to the value of nearly 647 millions, renders the field of great importance, even from the world point of view. From a South African standpoint, however, its significance is vastly greater, and the maintenance of the industry at something like the present level is a matter of vital importance to the whole country—a fact only now becoming apparent to the community at large. This will be the better understood when we consider that in 1920 the contribution to the country's revenue, through direct taxation and Government share of profits, amounted to £2,170,344, while the indirect contribution to the country's revenue, through the medium of railway rates on stores, etc., taxes on the incomes of mining employees, and in a multitude of other ways, was probably much greater still. In addition, the industry distributed in wages in 1920, nearly £17,000,000, and spent £14,288,247 on stores. It provides the best market for South African products, and proves itself in general a sort of foster mother to most other branches of industry."

Perhaps nothing in the history of the Witwatersrand gold field has tended towards the realisation of the intimate way in which its fortunes are interwoven with those of the country in general, and of how far-reaching are its connections with the trade and prosperity of districts so remote from it that they could hardly be expected to be affected by it, more than the recent upheaval on the Rand due to the strike and the other complicated social and political movements which followed in its train. It is fortunately not in my province to go into these, but only briefly to call attention to the effects on the rest of the country of the temporary paralysis of what many people are inclined to regard as a local mining industry.

The manner in which the cessation of mining activity, even for a comparatively short period, made itself felt in centres far remote from the Rand, as recorded in the press at the time, was one of the most striking consequences of recent events.

With the Witwatersrand before us as an illustration, it is unnecessary for me to labour the importance to be attached to a big mining field in a country where industrial concerns in other branches of industry are as yet in the early stages of development.

It will be more profitable, perhaps, to review briefly the very varied phases which may be passed through in the growth of a mining field, and to consider in what directions those engaged in scientific pursuits may be called upon to assist in its development.

For the discovery of a possible future mine or a mining field, we are accustomed to look to the prospector, a class under which

are included a great variety of types. The really good prospector must possess quite a special combination of qualities. The success of many men in this particular sphere who have not any special technical training is sufficient to show that such training is not an essential qualification, although it is undoubtedly a very desirable possession.

A compelling desire for the free life which prospecting usually involves, shrewd observation, untiring physical energy, an instinct for minerals, and, above all, an inveterate optimism, are the qualities most required.

That this is so will be obvious from the well-known fact that the born prospector rarely abandons his occupation, although so few ever attain a material reward in any way adequate to the energy they have put into its pursuit. This can scarcely be wondered at when we consider the few mineral occurrences which ever reach beyond the earlier stages of what may be called actual mining propositions. The Inspector of Mines for the Pretoria district showed in a recent report that the proportion which were so fortunate amounted only to some 5 per cent., the remaining 95 per cent. proving of no material worth, and this percentage is borne out by experience in other parts of the world.

In what are usually referred to as the "early days" in this country, we were, I believe, possessed of a considerable number of really good prospectors, attracted here from many other parts of the earth by the early gold discoveries. I am not at all sure that we possess many such men to-day, the reason being perhaps partly that newer fields have always the greatest attraction for the prospector, and partly the poor inducement offered to such men in South Africa to-day. One cannot help feeling that the conditions under which the prospector works, and especially those affecting his ability to secure the reasonable fruits of his labours, might be greatly improved.

One of the reasons why prospectors reap so little advantage from such finds as they make is, perhaps, their disposition to attach more importance to an immediate recompense in money than to the retention of a share in whatever the future may hold for the mineral deposits they may discover.

The prospector pure and simple is most likely to succeed with those mineral deposits which are more or less of a sporadic kind, whose presence cannot be inferred from the wider principles of geology, and whose exposure at the surface and consequent discovery involve a large measure of chance and good fortune.

Without doubt, many sporadic deposits are lying quite close to the surface, but sufficiently well hidden by superficial deposits to escape discovery by the methods of the ordinary prospector. It is interesting, in this connection, to speculate as to whether scientific effort will furnish any practical additional means of prospecting for such aggregations of minerals. Recent advances, especially those made in connection with the late war, in methods of detecting the presence of bodies which could not

be located by other means, seem to justify the expectation that before long prospecting for certain classes of mineral deposits may be carried out on somewhat similar lines. In the case of compact ore-bodies similar to those of Broken Hill and Tsumeb, such a means of investigation appears to possess considerable prospects of success.

With another type of ore body, we must look for new discoveries on quite different lines. I refer to those classes of mineral deposits which accumulated experience has shown to depend upon fairly definite geological conditions and analogies, established as the result of evidence brought together by the systematic scientific study of a large number of similar occurrences. Here the work of an organised and systematic geological survey becomes one of the greatest value from the point of view of the seeker after new mineral fields, as it also does in tracing possible extensions of fields already working, and the recognition of areas similar to those in which the existence of mineral deposits of particular types has already been proved.

Thus, in such cases as the tracing of the extension of the gold-bearing reefs of the Witwatersrand under the far Eastern portion of that district, in the location and exploration of new coal fields, and in the systematic boring of possible oil fields, organised geological survey work becomes of the greatest importance, and its value is thoroughly recognised, even by those who view the question entirely on hard business principles.

It is difficult to refer to this aspect of my subject without calling attention, as attention has been called many times before, to the very meagre support given by the Government of this country to geological investigation, especially as compared with the expenditure on other departments of scientific work—for example, those connected with agriculture. It still remains a striking anomaly in South Africa that the industry which suffers the greatest incidence of taxation is the one which benefits so little by Government aid to the sciences most nearly related to it.

When a mineral deposit of some promise has been discovered, either by a lucky strike by a prospector working more or less haphazard or by the more logical and systematic methods of the trained engineer or geologist, in many cases aided by the accumulated observations of an organized geological survey, its further development into a paying mining proposition is often a somewhat complicated process, than which there are few things less understood by the average person unconnected with the mining industry. It is often impossible, even for the expert, to foretell what the calibre and possibilities of a mineral occurrence may be without more or less exploratory work being carried out. This requires the expenditure of money, on a very speculative basis, which in many cases never yields any profitable result. Such work, therefore, usually falls to the lot of a small syndicate of more adventurous spirits who are willing to take the long odds against any return from their venture.

Should the find stand the test of such exploration and prove to be really of importance, it then stands in need perhaps of much more capital for its proper development than the small syndicate can command, and more powerful financial forces must be called in to carry the development a stage further. So perhaps at last a really large mining concern may come into being, or, as in the case already instanced, that of the Rand, the formation which is investigated may be found to be continuous over a large area, and an important new mining field may be developed.

It might be thought that when a mining field had attained to the productive stage on a large scale, its future would be simple and easy. It seems, however, that when such a happy position has been attained, our mining field may enter upon a second period of uncertainty from quite a new set of causes. There are undoubtedly gold mines on the Rand of which it can be confidently asserted that, as far as the intrinsic value of their contents goes, they involve none of the risks usually associated with gold mining, yet have had new elements of uncertainty added from quite outside sources.

The very importance to the community as a whole of such a mineral deposit as that of the Witwatersrand attracts to it the notice of the politician, the labour reformer, and the tax gatherer. This aspect of the subject we had, however, better leave to some other section of the Association, for it passes out of the sphere of ours.

Before leaving the subject of the development of a mining field, it will be interesting to compare the conditions where a mineral like coal is concerned, with those obtaining where gold is the product.

Gold has always possessed a great advantage over other mine products, in that the uncertainties connected with mining it were mainly at one end of the process. The price of the product has long been more or less fixed, and the market is practically unlimited. Moreover, it does not matter whether the miner produces a pennyweight or a ton of gold, he can sell it equally well at a more or less fixed price, and, moreover, the transport of his product is easy and the cost of it bears but a small proportion to the total value.

With a product like coal, however, especially in a young country like South Africa with its possible manufactures undeveloped, the internal market is limited, and the only means of developing a big coal mining field is by finding an outlet for surplus production, which, in this case, means the establishment of a sufficiently large trade in coal for bunker and export purposes.

This depends upon quite other considerations than those of mining, more especially upon the ease and cheapness of transport and the facilities for handling coal at the port through which it is shipped, for, to develop a shipping trade, delivery must be prompt and certain. This is of special interest to us here, for Delagoa Bay is the natural outlet through which a great export

trade might easily be carried on, were adequate facilities for dealing with such traffic available.

As I showed in a recent paper read before the Geological Society, there has recently been proved in the Transvaal, by systematic boring, a large extension of the Witbank Coal Field, in which has been definitely located not less than a thousand million tons of high grade coal, which is so easily accessible that it could be got out in almost any desired quantity just as soon as a market and a suitable outlet can be found. In this case it happens that, although a big new mining field has been proved and made ready for exploitation, its further development is suspended because of the absence of transport facilities, or from other causes, so that the full development of such a mining field often lies outside the power of the geologist and mining engineer.

However, it would be much more difficult to create a coal field than to improve existing means of transport, so that, no doubt, the difficulties in the way of the further development of our coal resources will be overcome.

Before leaving the subject, it may, however, be interesting to note that the influence of an important mining field extends beyond the sphere of ordinary commercial or industrial activity. Sooner or later a stage is reached when assistance is required from branches of scientific work other than geology or ordinary mining practice. In the case of the Rand particularly, the development of the gold field to its present stage has had important results in connection with matters with which we perhaps, as workers in various fields of science, are more directly concerned.

In the domain of chemistry and metallurgy, the problem of treating the pyritic gold ores of the Rand, which arose early in the history of the field, stimulated the work of perfecting and extending, if not of initiating, the cyanide treatment of pyritic ores—a process of world-wide application and importance.

At the present time, the problems connected with mining at depths much greater than usually attained—problems which are likely to attain still greater importance in the future, particularly those connected with ventilation and transport—give scope for new applications of science in special branches of engineering.

The former prevalence of silicosis among white miners has, in the domain of medicine, led to special research in connection with this occupational disease, which has resulted in a much better understanding of the conditions under which it arises, and in almost eliminating it from the list of the many dangers attendant on mining operations.

The utilization of great numbers of natives in mining work, and the importance of safeguarding them as far as possible from diseases to which they are more particularly liable, such as pneumonia, has led to organized research which has achieved most important results applicable over a much wider sphere. This invaluable work would probably have still remained undone, had it not been for the importance attaching to it in connection with

a big mining field, able to provide the means and material for carrying out the necessary investigation.

Even on the smaller mines, many problems arise outside actual mining, which require the aid of allied sciences. This is perhaps especially the case in those mines in which the ore-bodies are of a complex nature, and include a comparatively large variety of minerals, frequently forming an aggregate which is very difficult to deal with, and there is no doubt that there still remains an extensive field of research of an interesting and profitable nature, in the investigation of both the chemical and physical constitutions of some of these complex ore-bodies. It seems likely that, by adopting some of the methods of microscopical investigation which have come into use in connection with nearly allied lines of study, some very important results might be obtained in the near future.

In connection with education also the development of big mining centres may have an important bearing on the progress of a young country.

The necessity for local training in scientific and technological subjects which exists, leads to much greater demand for instruction and opportunities for research in these directions, while, at the same time, the disposition to afford them financial support from local sources is proportionately increased. In the case of the Witwatersrand this has allowed of the establishment of a University.

The development of an extensive mining industry in our midst had resulted already in the provision of exceptional facilities for the study of mining problems, which are likely in the future to attract advanced students from other parts of the world, whose presence among us will, no doubt, be of benefit to all concerned.

I have said enough, I think, to show that, in the earlier stages of a country's history, the exploitation of mineral deposits may have a most important influence. In this country we have been exceptionally fortunate, in that, in the case of the gold industry at least, we possess a field sufficiently extensive and stable to exert more than a temporary influence on the country generally —an influence which is sometimes perhaps not fully appreciated by those not directly connected with mining, and one which is of special interest to workers in many branches of science.

CARBON ASSIMILATION.

BY

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Presidential Address to Section C, delivered July 12, 1922.

In expressing my appreciation of the honour of being selected as President of Section C for this meeting I ask your indulgence if I refer to a circumstance that makes the occasion one of more than merely personal gratification to me. For the first time in the history of the Association, the occupant of this chair represents as his chief scientific interest the physiological side of botany.

It is only natural that in a young country with a flora so rich and fascinating, South African botanists have paid more attention to the systematic study and collection of that flora, its geographical distribution and general ecology, and to the morphology of the specially interesting and unique plants with which it abounds, than to the more general or abstruse problems of plant life.

Work in these directions is useful and necessary. There still remains much essential spade work to be done even in the collection and determination of plants. There are signs, however, that South African botany is developing beyond this essential preliminary phase and that the time has arrived when more attention will be paid, along with other fundamental branches of the subject, to plant physiology. I do not think I shall be accused of partisanship if I urge the paramount claims of this field.

The study of plant physiology, requiring, as it frequently does, elaborate and expensive apparatus, presents special difficulties in a country at an early stage of industrial development and so far from the skilled instrument makers to whom European and American scientists have ready access. But for a community which is largely agricultural this branch of botany is of fundamental importance. The nutrition and growth of plants form a very large part of its subject matter and these are the daily practical concern of the farmer. It is therefore greatly to be deplored that the staffs of the Agricultural Colleges and Experiment Stations of the Union do not include one plant physiologist.

It is to some extent true that plant physiology is applied chemistry and physics, but this is by no means wholly true—not yet, at any rate. Even were it so, chemists and physicists as such lack an essential part of the equipment which is necessary for the solution, or even the clear realisation and analysis, of

many of the physiological problems suggested by agricultural practice and its difficulties. A plant physiologist is a botanist as well as something of a chemist and a physicist. He needs the co-operation of the chemist and the physicist, but his special equipment enables him to co-operate with them in return, bringing an experience of the research methods appropriate to the study of plant functions and an intimate knowledge of the plants themselves.

This is realised in Europe and America. In the United States especially, representatives of various branches of plant physiology are attached to the staffs of the Agricultural Experiment Stations and much valuable work has been accomplished by them.

There are various physiological subjects of obvious practical application to which I might have asked your attention on this occasion. I feel, however, that I could hardly do justice to them in relation to the special problems of this country, because my residence here has not been long enough, and in Cape Town I have not had opportunities of obtaining a first hand acquaintance with agricultural conditions and practice. The subject I have chosen is, however, one which ranks second to none in fundamental importance.

The assimilation of carbon dioxide by the green plant is a process on which depends the whole of the food supply of the plant and animal worlds. It underlies the food supply of the human race. The accumulations of carbonaceous matter by plants of past geological epochs supply, moreover, in the form of coal, the source of power for the bulk of our manufacturing processes. Much has been heard recently of the possibilities of alcohol as a source of power. This alcohol is also ultimately derived from the products of the photosynthetic activity of the green plant, and, like coal, represents a store of potential energy obtained from the radiant energy of sunlight. This process well merits the title of "cosmic function," which was first, I believe, conferred upon it by Timiriazeff, that distinguished Russian plant physiologist of whose death this year we have learned with regret.

During the last twenty or thirty years our knowledge of this function has been notably enlarged. Two names are chiefly associated with the progress that has been made, those of F. F. Blackman of Cambridge, and Willstätter of Berlin. Much of the work of Blackman and his school is already well known. That of Willstätter and his collaborators is more recent and, partly owing to the War, is less familiar to botanists than its importance demands.

Blackman's great achievement has been the successful analysis of the influence of external conditions on the rate of assimilation, which has laid the foundation for a deeper knowledge of the process itself. Willstätter has established on a firm basis our knowledge of the pigments of the green chloroplast and given us a further glimpse into the internal mechanism of the process. The work of both has applications which extend beyond

the immediate aims of their investigations. To some applications which are of ecological interest I will refer later.

I wish first to outline very briefly and without attempting to enter into detail some of the main results.

Blackman's principle of limiting factors* still holds the field in spite of criticisms from various quarters. It states that a process is limited in rate by that factor which is present in least relative concentration or intensity.

For carbon assimilation, under any given set of conditions of light intensity, temperature and carbon dioxide concentration, only one of these will ordinarily be the limiting factor, and the rate of assimilation can be raised only by increasing this factor. Increasing the others is without effect as they are already in relative excess.

Thus, under the conditions ordinarily occurring in nature, the low percentage of CO_2 in the atmosphere is the limiting factor on a sunny day. The light is more intense and the temperature higher than is necessary to enable a green leaf to assimilate the whole of the CO_2 that can reach the chloroplasts. When the CO_2 supply is artificially increased the rate of assimilation rises proportionately. Increasing the light intensity on the other hand is without effect, while raising the temperature not only does not increase the rate, but, if carried far, reduces it by lowering the efficiency of the leaf.

In the early morning and late evening, the low intensity of light does not supply sufficient energy for the assimilation of the CO_2 as fast as it could reach the chloroplasts. Under these conditions it is light which acts as a limiting factor.

In very cold weather, the low temperature reduces to a low level the maximum rate at which a leaf can work and temperature is then the limiting factor. In this case even an increase in the supply of CO_2 is without effect.

Examples illustrating similar relations under experimental conditions are already numerous in the literature. The experiments of Blackman and Matthaei with natural illumination†, of Brown and Escombe‡ on the effect of varying partial pressures of CO_2, of Blackman and Smith on water plants§, and more recently those of Willstätter and Stoll on assimilation in relation to temperature and light‖ may be cited in this connection.

There is one aspect of this principle of limiting factors which has not, I believe, until quite recently been clearly stated, but which must be taken into consideration if the principle is to be appreciated at its true value.

According to the well known chemical "Law of Mass Action," if two substances react together the rate of reaction is

* Annals of Botany, 19, 1905, p. 281.
† Proc. Roy. Soc., B. 76, 1905, p. 402.
‡ Proc. Roy. Soc. B. 70, 1902, p. 397.
§ Proc. Roy. Soc., B. 83, 1911, p. 389.
‖ Untersuchungen über die Assimilation der Kohlensäure, Berlin, 1918.

proportional to the product of their concentrations. Increasing the concentration of either substance increases this rate. It can also be increased further by raising the temperature. Clearly the principle of limiting factors is not applicable to simple direct reactions of this type, between substances in solution. That it does hold for assimilation is in itself a demonstration of the complexity of the process. It is at least probable that to each of the external limiting factors corresponds a distinct stage of the process which is dependent upon it. The rate of the process as a whole is in reality determined by the rate of the slowest contributory stage, as has been pointed out by Briggs.*

If the process is complex, it is to be expected that the internal mechanism which carries out the process is also complex. One factor in this mechanism is obviously the green pigment chlorophyll, in the absence of which there is no assimilation of CO_2. It has long ago been inferred, from the sensitiveness of the process to poisons and other influences that lower the tone of the organism, that the protoplasmic stroma of the chloroplast also plays a part.

The first direct evidence that chlorophyll is not the sole agent was furnished by Miss Irving's experiments, carried out in Blackman's laboratory, with etiolated leaves†. The leaves used in her investigation turned green many hours before they began to assimilate. Some other essential part of the assimilation mechanism must therefore have lagged behind the chlorophyll in its development.

Willstätter and Stoll‡ failed to obtain the same results when they attempted to repeat Miss Irving's experiments, but they have recently been confirmed and extended by Briggs, again in Blackman's laboratory. Briggs has shown that the second factor develops gradually in the dark so that whereas a leaf a few days old will turn green without at once being able to assimilate, an older one will begin to assimilate as soon as chlorophyll appears. It is a puzzling fact that, while the leaf is deficient in this factor, the rate of assimilation is limited by the intensity of light. The activity of this factor is therefore dependent upon light and it must belong to the photochemical part of the mechanism.§

We must now turn to Willstätter's contributions to our knowledge. His experimental investigations on the assimilation of carbon dioxide in collaboration with Stoll, which were published in book form in 1918,|| are a sequel to his fundamental

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* Roy. Soc. Proc., B. 91, 1922, p. 249.

† Annals of Botany, 24, 1910, p. 805.

‡ Loc. cit. p. 127 et seq.

§ The analogy of a photographic plate is useful in this connection. Light brings about a photochemical reaction the rate of which depends upon the intensity of the light but is little influenced by temperature. Subsequent development on the other hand takes place in the dark—*i.e.*, it is not a photochemical process—and its rate is greatly influenced by changes of temperature.

|| Loc. cit.

work on the pigments of the chloroplast. The elucidation of the nature and composition of these pigments is a monumental achievement in the domain of plant chemistry. The work of previous investigators had demonstrated the existence of both green and yellow pigments, but there was a conspicuous lack of agreement on many important questions, especially as to their number, composition and properties. The success of Willstatter and his school is due to the skill and care with which the pigments were separated and obtained in an adequate state of purity, the large scale of their operations and their thorough and systematic study of the pigments themselves and their decomposition products.

It is now established that two green pigments, and two only, exist in the chloroplast, one blue green and the other a pure green in solution. Willstätter calls these chlorophyll *a* and *b* respectively. Both are present, though in slightly varying proportions, in all the numerous green plants he studied. They differ but slightly in composition. Chlorophyll *a* always preponderates. Besides these two green pigments there are two yellow pigments, carotin (the pigment of carrots) and xanthophyll, which are also closely related to each other. In the Brown Algae there is very little chlorophyll *b* and along with carotin and xanthophyll a third closely related yellow pigment, fucoxanthin, is present; but the living thallus contains no pigment corresponding to the phycophaein of the older textbooks.

Willstätter and Stoll were unable to obtain any evidence that the yellow pigments play a part in photosynthesis. Using yellow leaves poor in chlorophyll, in which the yellow pigments preponderate, they observed no appreciable reduction of the rate of assimilation when the more refrangible rays of light, specially absorbed by these pigments, were intercepted by a suitable filter, notwithstanding that the light was the limiting factor.

Having devised a means of separating and determining the chlorophylls quantitatively, they undertook parallel determinations of chlorophyll content and rate of assimilation for a wide range of leaves, in order to find out whether and, if so, how the rate of assimilation depended on the amount of chlorophyll present. They summarise their result in the form of "assimilation numbers" which represent the number of grams of CO_2 assimilated per hour by one gram-molecule of chlorophyll. Most of their assimilation experiments were carried out at 25°C. in light of about the same intensity as direct sunlight, with an abundant supply of CO_2. Under these conditions they showed that for normal green leaves the temperature was the limiting factor.

The assimilation numbers vary from about 5 to 16, the larger numbers being given by herbaceous plants, like the sunflower, noted for their rapid assimilation and vigorous growth. These variations would be sufficient by themselves to throw doubt on

‡ Willstätter and Page, Ann. d. Chem. 404, 1914, p. 237.

the existence of any direct relation between chlorophyll content and rate of assimilation while temperature is the external limiting factor.

Comparison with yellow varieties of leaves rendered the absence of such a relation strikingly evident. These leaves contain a low proportion of chlorophyll. Nevertheless their rate of assimilation did not fall far short of that of normal green leaves of the same species, and their assimilation numbers were therefore high, ranging in extreme cases up to 140. This means that in light of the intensity of direct sunlight the small amount of chlorophyll present was sufficient for the assimilation of nearly as much CO_2 as was assimilated by the much more abundant chlorophyll of the green leaves. Willstätter and Stoll infer that in the latter there is far more chlorophyll than is needed, even for the enhanced rate of assimilation which obtained in their experiments with a practically unlimited supply of CO_2. It follows that some other slower agent is also concerned, and, since temperature was the external limiting factor, that the rate of action of this agent is dependent upon temperature. As most ordinary chemical reactions, including those brought about by enzymes, show a similar dependence upon temperature, Willstätter and Stoll call this part of the assimilation mechanism the "enzymic factor." The stage of the process for which it is responsible is not photochemical, and it must therefore not be confused with the factor which developed later than chlorophyll in Miss Irving's experiments.

In the case of the yellow leaves light proved to be the external limiting factor even when its intensity was raised above that of sunlight. The enzymic factor is therefore not working up to its full capacity. As the light diminishes in intensity the rate of assimilation diminishes. There are also indications in some of the experiments of a rough proportionality between rate of assimilation and chlorophyll content; but in view of Brigg's demonstration of a second photochemical agent we are left in doubt as to whether in any particular case it is this or chlorophyll which is determining the rate. Nevertheless it is on the whole clear that the higher intensity of light required by yellow leaves to enable them to assimilate as rapidly as green leaves is correlated with their lower chlorophyll content; and we may suppose that under certain conditions the photochemical stage is determined jointly by light and chlorophyll.

The demonstration of the plurality of internal agents raises the question of their respective rôles. Here, however, we are still very much in the dark. Willstätter and Stoll have not yet taken Brigg's second photochemical factor into consideration, but they have made some interesting contributions towards a solution of the general problem and the theory they put forward is of sufficient interest to warrant a brief statement of it. As it is based upon the chemical composition and properties of chlorophyll an outline of their main conclusions in this direction* may first be given.

* Untersuchungen über Chlorophyll, Berlin, 1913.

The two green pigments, chlorophyll *a* and *b*, are fundamentally similar in their chemical constitution. Willstätter and Stoll found no change in their relative proportion, even during intensified assimilation under their experimental conditions, nor in their total amount. They infer that both function similarly in photosynthesis. The empirical formulæ only differ in the replacement of two atoms of hydrogen in *a* by an atom of oxygen in *b*. Along with this difference goes a slight difference of colour and absorption spectrum; but we can refer to both together as chlorophyll in treating of the construction of their molecules as elucidated by Willstätter.

Chlorophyll is a complex organic compound containing in the molecule one atom of magnesium, but no iron, notwithstanding the fact that in the absence of iron plants fail to form a normal amount of chlorophyll. The magnesium is readily removed by acids, even by weak organic acids. As the characteristic colour of the chlorophyll disappears at the same time it is clear that its behaviour towards light, which is fundamental to its rôle of absorbent of radiant energy in photosynthesis, must depend on this magnesium atom and its mode of union with the rest of the molecule.

The colourless *phaeophytin* which is obtained from chlorophyll by removal of the magnesium does not otherwise differ in constitution from the chlorophyll in any fundamental respect. On carefully graded treatment with alkalis each gives a series of less complex products, one series containing magnesium and green in colour, the other free from magnesium and not green. Each of the former when treated with dilute acid gives the corresponding member of the magnesium-free series.

Although the magnesium is not removed by treatment with alkali and the products obtained are green, the first stage of the treatment is marked by an evanescent change of colour from green to brown. Willstätter and Stoll attribute this to a change in the magnesium complex whereby a condition of greater stability is reached: the brown phase represents the intermediate unlinking, probably of a closed ring which is reformed in a different way with reappearance of the chlorophyll green.

In the final product of saponification by alkali, namely, aetiophyllin, the magnesium is still present. Willstätter and Stoll represent it as united to the nitrogen atoms of two salt-forming pyrrol rings and probably also more loosely to the nitrogen of two other pyrrol-like complexes, which constitute with the other two pyrrol rings the central nucleus of the molecule. It is an extraordinary coincidence that the nucleus of the hæmoglobin of blood is very similar in construction, but contains iron in place of magnesium.

Around this nucleus are attached various side chains of carbon and hydrogen. In chloropyhll itself there are also two carboxyl groups, in one of which the hydrogen is replaced by a methyl group, in the other by the radicle of a complex alcohol

to which the name phytol is given. Alkalis first saponify these ester side-chains giving salts of the corresponding dicarboxylic acid, chlorophyllin.

The waxy amorphous nature of chlorophyll and its colloidal properties are to some extent bound up with the phytyl radicle. Willstätter and Stoll have shown that an enzyme occurs in the living leaf, called chlorophyllase, which in the presence of ethyl alcohol replaces the phytyl by ethyl. The product of this exchange is a substance known as "crystalline chlorophyll," which is deposited in crystalline form from alcoholic solutions. True chlorophyll does not crystallise.

It is clear from the facts here briefly outlined not only that the optical properties of chlorophyll are bound up with the magnesium atom, but also that in true chlorophyll this atom is combined in such a way as to give the complex a peculiar mobility. This is revealed by its behaviour towards alkalis as well as by its sensitiveness to acids. It appeared to Willstätter and Stoll highly probable, therefore, that chlorophyll plays a chemical as well as a purely physical part in the assimilation of carbon dioxide, and they set themselves to obtain direct evidence of this by investigating the behaviour of pure chlorophyll towards this gas.

In alcoholic or ethereal solution they found no evidence that CO_2 (anhydrous) is taken up by chlorophyll. Chlorophyll solutions absorbed no more than the pure solvents. Colloidal solutions of chlorophyll in water, on the other hand, absorb more CO_2 than pure water. The limit is reached at two molecules of CO_2 to each molecule of chlorophyll with decomposition of the chlorophyll, giving phaeophytin and magnesium bicarbonate. Here carbonic acid acts like other weak acids, removing the magnesium. The decomposition is not, however, simple and direct. Willstätter and Stoll succeeded in obtaining clear evidence of an intermediate addition compound which can be completely dissociated into unaltered chlorophyll and carbonic acid. On this basis they propound the theory that in the assimilation of CO_2 by the chloroplast this addition product is first formed, and that the enzymic factor then decomposes it into free chlorophyll, oxygen, and the formaldehyde residue from which carbohydrate is synthesised.

The formation of the addition product is apparently independent of light. Willstätter and Stoll suppose that the absorption of light results in a change in its configuration which makes it susceptible to the enzymic factor.

This theory provides three stages, each dependent upon one of the three external factors which, according to Blackman, act as independent limiting factors—a feature which tells in its favour. But it has yet to be learned what Briggs's second photochemical agent is and what part it plays. Leaving therefore many other suggestions that Willstätter and Stoll make of a more hypothetical nature, reference may be made to an aspect of the subject which is of special interest to South African botanists.

In this climate the plants of the open veld are daily exposed during the greater part of the year to the full blaze of the sun. Now both Blackman and Willstätter have shown that direct sunlight is far more intense than is necessary for the assimilation by normal green leaves of all the CO_2 that can reach the chloroplasts from the atmosphere, and even for the maximal assimilation possible, when the supply of CO_2 is not limited, at a temperature higher than 25°C.

Blackman and Matthaei's calculations of the photosynthetic value of full sunlight, though they are based on the doubtful assumption that the rate of assimilation is proportional to the intensity of the light, when temperature and CO_2 supply are in excess, nevertheless gives an approximate basis for calculating the proportion of direct sunlight which is used under the most favourable conditions in nature.

The highest figures for the rate of assimilation in the open air have been obtained by Sachs* for *Helianthus annuus,* which I confirmed† in 1910, and for the cotton plant in Egypt by Balls‡ whose results are somewhat higher. These figures represent the utilisation of about 30 per cent. to 35 per cent. of direct sunlight. Most leaves utilise not more than 10 to 20 per cent. calculated on the same basis.

Willstätter and Stoll have shown, moreover, that the normal green leaf contains far more chlorophyll than is necessary to enable the chloroplasts to assimilate up to their full capacity in direct sunlight, for yellow varieties of leaves with far less chlorophyll assimilate nearly as rapidly.

They suggest, therefore, that the large chlorophyll content of the normal leaf is an adaptation to lower intensities of light. From this point of view it is interesting that shade leaves contain more chlorophyll, bulk for bulk, than sun leaves of the same species.

Yellow varieties of leaves stand in marked contrast to green leaves, for even direct sunlight is not intense enough to enable the chloroplasts to assimilate at the maximum rate made possible by the temperature, and even with ordinary atmospheric air the intensity of light required to assimilate all the CO_2 diffusing to the chloroplasts will be very much greater for yellow than for green leaves. We may, in fact, regard yellow leaves as light demanders *par excellence.*

Now, if we compare the generality of plants in the more open types of vegetation, and even the relative light demanders of forest fringes, with the vegetation typical of our forests, we cannot but be struck by the depth of the green colour of the forest trees and the lighter colour of the light demanding plants.§

* Arbeit. d. Bot. Inst in Würzburg iii, 1883, p. 19.
† Proc. Roy. Soc. B. 82, 1910, p. 421.
‡ Nature, 89, 1912, p. 555.
§ *Leucadendron adscendens* and *Galenia africana* may be cited as extreme examples.

In attempting to interpret this contrast there are, however, other features to be considered besides chlorophyll content. As Willstätter and Stoll have emphasised, light penetrating a leaf does not pass directly through it, but is reflected and refracted in various directions by the cell walls, especially where these abut on air spaces. The bright colour of yellow leaves is due chiefly to light that is reflected back within the leaf and emerges from it again. In a green leaf the bulk of this light is absorbed before it escapes, when passing the deep green chloroplasts.

The contrast in colour between the upper and lower sides of a leaf with palisade tissue above and spongy tissue below is due partly to the greater development of air-spaces and consequent frequency of transverse reflecting surfaces in the spongy tissue, the absence of which renders the palisade tissue more transparent so that light penetrates it more deeply; partly also to the narrowness of the palisade cells which therefore interpose numerous layers of chloroplasts in the path of rays that are traversing them at all obliquely. It follows from the latter consideration that the narrower the palisade cells the more complete will be the absorption of light passing through them, including that reflected back, and therefore the darker green will the leaf appear.

Some preliminary measurements made in my laboratory by Miss E. K. Tredgold support the impression I have received from my own observations that the dark green leaves characteristic of our evergreen forest vegetation have narrow palisade cells, whereas the lighter coloured leaves of the Proteaceæ, for example, have wide palisade cells.

The complementary fact seems also to be very significant, namely, that wide-celled palisade tissue must also be more transparent and allow a larger proportion of the light to penetrate it unfiltered by chlorophyll. Willstätter and Stoll found that shading a leaf of *Cucurbita* by a second leaf reduced its rate of assimilation to very low proportions, even when light of the intensity of direct sunlight was employed, and they emphasise the importance of leaf mosaics in this connection. What applies to leaves must also apply to chloroplasts. The larger the number of chloroplasts light has passed the less will be its photosynthetic efficiency. It seems legitimate to infer that there is a limit to the profitable depth of palisade tissue and that this limit will increase with the width of the constituent cells, as well as with the average intensity of light that prevails. It is hardly a mere coincidence that the leaves of the Proteaceæ have wide-celled palisade tissue extending from both sides almost from one epidermis to the other.

Greater transparency of the palisade tissue not only allows light of good photosynthetic quality to penetrate to a greater depth, but it also means reduced absorption bulk for bulk and less heating effect. The importance of this can be gauged in view of the high internal temperatures that have been demonstrated

by Blackman and Matthaei,* and by A. M. Smith in leaves exposed to direct sunlight. Smith for example observed in Ceylon temperatures as much as 15°C. higher than the shade temperature of the air.

Analogous considerations are suggested by the disposition and form of the leaves characteristic of the maquis of the South Western part of the Cape Province. The broader leaves are usually inclined upwards or assume the profile position, as in *Protea grandiflora*. Their foliage, therefore, does not cast a dense shade like the horizontally displayed leaves of most forest trees. The leaves do not shade one another to the same extent but allow more light to pass unfiltered, both between them and reflected from their outer surfaces, to the leaves below. Like the transparency of the palisade tissue, the transparency of the foliage also means a diminution in the heating effect.

Similarly, the foliage of plants with small or dissected leaves, which are so characteristic a feature of this type of vegetation, is relatively transparent. I have on a former occasion drawn attention to the inadequacy of the traditional view that microphylly is a xerophilous adaptation in that it reduces the transpiring surface. Small leaved plants usually have very numerous leaves and the total surface exposed may be very considerable. Besides, the more slender the leaf the larger surface it exposes per unit of volume. The same applies to such dissected leaves as those of *Athanasia parviflora* and of the Australian *Hakea spp.* with cylindrical segments. These expose as much surface relative to their volume as flat leaves of half the thickness.

The ecological interpretation of these leaf types is, however, a complicated problem. I will merely refer again to the transparency of foliage composed of such leaves and offer another suggestion which appears to me to present the xerophilous aspect of microphylly in a truer perspective. I base it upon some results obtained by Yapp in his study of the vegetation of the Fens of Eastern England, and on the recent work of Farmer on the resistance of wood to the flow of water to the leaves.

Yapp† found that, when shoots of the Meadow Sweet (*Spiræa ulmaria*) were suffering from a deficiency of water, those parts of the leaves which were farthest from the main veins were the first to dry. These parts are, therefore, less efficiently supplied with water by the conducting channels. The lower leaves of this plant, produced in the shelter of surrounding vegetation, are glabrous. The uppermost leaves fully exposed to the sun and wind are hairy. Intermediate leaves developing under less extreme conditions bear hairs on just those parts which are the first to dry up in case of drought.

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* Proc. Roy. Soc. B. 76, 1905, p. 402.
† Annals of Botany, 26, 1912, p. 815.

Farmer* has emphasised the importance of the varying resistance offered by wood to the passage of the transpiration current. As a result of numerous measurements he has made the important generalisation that the wood of most xerophilous plants offers a relatively high resistance to the flow of water. The significance of this fact can hardly be sought on adaptational lines. In the light of it, however, it is easier to understand why the leaves of different plants growing in the same habitat should be so unequally protected against excessive transpiration. Moreover, any structural feature which reduces the resistance to flow of water to the mesophyll of the leaf will diminish the danger from rapid water loss. Yapp's observations can be interpreted accordingly. Those parts of a broad leaf which are farthest from the main channels of supply have the greatest resistance to overcome.

Now in a dissected leaf, especially one with slender cylindrical segments, all the cells of the mesophyll are close to principal veins. The same applies also to small leaves generally, and especially to the extreme pinoid and ericoid types.

Cupressoid types represent a retention of the mesophyll still nearer to the main channels of supply in the stem. In this case the foliage as a whole almost certainly exposes a relatively reduced leaf surface; but to what extent this is true for microphyllous plants in general has yet to be determined.

With these suggestions I conclude my address. It has I fear been in parts abstruse, in parts rather speculative; but I hope that, following the example of our microphyllous leaves in relation to their water supply, I have not ventured to expand too far from established facts.

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* Proc. Roy. Soc. B. 90, 1918, p. 218 and p. 232.

SOME MODERN DEVELOPMENTS IN ANIMAL PARASITOLOGY.

BY

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Presidential Address to Section D, delivered July 12, 1922.

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INTRODUCTION.

Before commencing my Presidential Address to Section D, may I express my appreciation of the honour conferred on me in being thus chosen to address you. In selecting as my subject that of Animal Parasitology, it may appear that I am hardly in full agreement with my predecessor when he stated that "Science pursued for its own sake widens the outlook of the individual and trains his reasoning powers. 'Pure science' must never be ignored, for the apparently academic and 'useless' researches of to-day may be of the greatest technical benefit to-morrow."[1] With this opinion, however, I desire to identify myself to the full, for the pursuit of knowledge for its own sake

must be the goal; applications of knowledge will come later. The investigator is the one to whom the credit is due, not the one who merely sees in knowledge a means to the end for the production of wealth.

Pure science extends in many directions, and I think that in the domain of biology the directions are as numerous as in any field of work. Even where the attention of the worker may be theoretically confined to so-called "practical" investigations, it is possible, and ought to be essential, to maintain the standard of those less trammelled. Perhaps in no branch of biology is that more necessary than in the branch with which I am most associated, namely, parasitology. The subject is vast; there are many items of great interest therein; the literature is often not only scattered, but in journals difficult of access to many scientists, and these are some of the reasons for my choosing as a topic some recent advances in parasitology, perhaps with emphasis on the side of human parasitology, and necessarily with a wide element of selection in the subject matter. Consequently, certain aspects of parasitology as affecting plant life, human and other animal life and our general scheme of society will be touched upon.

The origin of parasites is undoubtedly from free-living forms. Scarcity of food and other unfavourable environmental conditions probably first caused the habit of living at the expense of some other organism, probably at first a dead organism. From saprophytism to parasitism many intermediate stages occur, and it is doubtful where one begins and the other ends. In certain groups of organisms such as the Cestoda, that are exclusively parasitic, links between allied free-living and parasitic forms are less obvious than in the case of such organisms as the Flagellata or the Nematoda, where free-living and saprozoic forms grade almost imperceptibly into one another, and thence on to parasitism. Here it is that morphology and embryology come into prominence, for it is by their study that the present forms can be linked with those of the ancestral stock. A sound knowledge of morphology is essential to the parasitologist, as indeed it is to any worker in any field of biology. To the parasitologist the minute anatomy, the life-histories and the habits of the hosts of the parasites studied are of paramount importance—a fact often overlooked by workers in other domains of biology, such as systemic or palæontological work, to mention only two fields. Attention to the value of morphology was recently emphasised by F. A. Bather, in a review of a book on the ancestry of the Echinoderms, and his remarks apply equally to the parasitologist, who should be a trained morphologist, and who, unless so trained, can and does draw unwarranted conclusions. Bather wrote: "Whoever discusses morphological problems should have regard to the recognised principles and methods of morphology. He should have a sufficiently wide knowledge of comparative anatomy to be able to estimate the relative values of the facts that he adduces. There is at the present time a real danger that this discipline may be forgotten in the rush after alluring discoveries in genetics, biochemistry and other novel branches of biology."

In connection with parasites, it may be noted that all forms of parasitism are more or less degrading; reproduction seems to be the chief aim. On the other hand, parasitism implies plasticity and often polymorphism, for the organism has to adapt itself to many changes of environment. In some cases the parasite has become so specialised in its physiological relations with the host that one phase of its life can be passed only in one host, a second phase, often one of rest or metamorphosis, in a second host, and the final or adult condition is attained only in a third host. Examples of such will be afforded later.

Specificity of parasites to one vertebrate host is often well-marked. In other cases, the parasites have greater powers of adaptation and can live in several hosts. Thus, the human tape-worm, *Tœnia solium*, is specific to man, but *Dipylidium caninum* of the dog can not only infect dogs, but can live in wolves, jackals, rodents, and occasionally man. Arthropod parasites, again, may be specific to their hosts, and, in some cases, the association of host and parasite occurred at a very early stage in the evolution of both groups. An instance of this rigid specificity is afforded by the Mallophaga parasitic on birds, as was shown by Harrison, who indicated how the systematic relationships of different Mallophaga are indicative of relationships of the genera of birds on which they occur. Incidental parasitism, the result of temporary or accidental association, is also known.

In connection with certain of the intestinal Protozoa, particularly Flagellata, numerous species have been created often merely on the criteria of size and of occurrence in another host. Morphologically, many of these organisms, such as species of Herpetomonas and Giardia, are almost identical; biologically, their life-histories are the same. Pathologically, they may have widely different effects on the hosts they infest. Potentially, all are capable of producing fatal effects on any new, susceptible host into which they may be introduced. As has been stated repeatedly and shown experimentally, the newer the parasite is to the host the more lethal are its effects. With age-long habituation to one host generations of parasites are produced that have inherited the mutual toleration established through such long association, and their pathogenic properties are either sublimated or reduced.

At the same time, it seems to me highly probable that many species of parasites will ultimately prove to be varieties of the same organism, the primitive strain having been acted upon by different environments, charged with slightly different potentialities as a result of their reactions with these environments, and finally modified slightly morphologically in accordance therewith. Just as the chemist and the physicist have worked together to find the universal ion, with numerous potentialities, each combination resulting in differences of form and constitution, so it seems possible that the parasitologist, after prolonged study of the numerous environmental factors that may be at work, will arrive at the condition of affairs where there is a universal trypanosome, herpetomonad or other genus of parasites, modified according to its environment and potentialities.

Another feature of interest is the occurrence of multiple factors in disease. Thus, in coccidiosis of grouse, Fantham found that, in some cases, there had been a secondary invasion of the tissues by bacteria, the merozoites of *Eimeria avium* having acted as inoculating needles for the bacteria. It is probable that there are similar occurrences in other infections, and it is suggested that while the migrations of Ascaris larvæ through the abdomen and lungs of man are in themselves injurious, they also aid in disseminating such organisms as tubercle bacilli. That the toxins of bacteria are of more pathological import than the bacteria themselves is known, as in the potato disease due to *Bacillus tumefaciens*. Some worms, as Ascaris, are also known to produce a toxin. Lysins are produced among other parasitic worms, and aid them in their passage through the tissues of the hosts.

While there is a fund of general information in regard to parasites left untouched, time, unfortunately, does not permit of their consideration, and attention may now be directed to certain recent researches in the domains of protozoology, helminthology and entomology, particularly the two former.

Protozoology.

Among the recent advances in Protozoology, the following may be considered:—

Amœbiasis.

In connection with the Sarcodina, discussion as to possible different races of *Entamœba histolytica* has arisen. Dobell and Jepps stated that there were at least five different races of *Entamœba histolytica* distinguishable from each other as shown by curves representing dimensions of the cysts. Recently Rodenhuis* controverts this opinion. He considers that there are different factors which may cause irregularity in the obliquity of curves. Such are (*a*) faulty technique in the measurement of cysts; (*b*) Amœbæ may encyst at different stages of growth, so producing cysts of different dimensions; (*c*) the conditions of life of the amœbæ are influenced by their environment, such as the diet of the host and variations in the intestinal fauna and flora. Also, it is not known for certain whether an amœbic strain changes its dimensions if transmitted from a carrier to another person. Some of Rodenhuis's observations on a family of carriers suggest that such a change may occur. Rodenhuis obtained curves that convinced him of the existence simultaneously of different races of *Entamœba histolytica* in one patient. He even considers that the small strains are a different Entamœba and names it *E. tenuis*, his final conclusion being that the exstence of different races within the species *E. histolytica* has not yet been proved.

Trypanosomiasis.

One of the needless controversies of relatively recent times has centred round the identity or otherwise of *Trypanosoma*

* *Trop. Diseases Bulletin*, xix, p. 331.

rhodesiense and *T. brucei*. The morphological differences described by the discoverers of *T. rhodesiense* (Stephens and Fantham) were emphasised by the numerous serological and immunological experiments* of Laveran, Mesnil and other French workers. Still, some continued to maintain the identity of the two species. An account by Taute and Huber† was published in 1919 that should end any controversy, as by inoculation experiments on the human subject they have shown that *T. brucei* will not develop in man.

In the first experiment Dr. Taute and eleven native criminals were inoculated with *Trypanosoma brucei* and none became infected. Next, Taute and Huber and 129 native carriers—members of eleven different tribes—were inoculated with virulent strains of *Trypanosoma brucei* obtained from naturally infected animals, and again no one contracted trypanosomiasis. The virulent nature of *T. rhodesiense* is too well known to need comment, and it can hardly be imagined that 143 persons could be inoculated with this virulent organism and none suffer from trypanosomiasis.

As regards treatment, attention may be directed to two new methods now in process of trial, namely, the injection of salvarsenised serum into the spinal canal, devised by Marshall and Vassallo, and the trial of a secret preparation known as Bayer 205 by the German investigators, Kleine and Fischer.

HERPETOMONIASES, INCLUDING LEISHMANIASES.

One of the most interesting problems of protozoology has been that of the insect flagellates and their significance, especially in their relation to the human diseases generally known collectively as the leishmaniases. Kala-azar, Oriental sore, and dermomucosal leishmaniasis are well-known tropical and semi-tropical diseases due to members of the Herpetomonadidæ, known as *Leishmania donovani* and *L. infantum* in the cases of kala-azar and infantile splenomegaly where generalised infection occurs, and as *L. tropica* in the more local maladies of the skin. In man and in dogs the organisms usually are present in the non-flagellate condition, but in cultures they develop into typical Herpetomonad flagellates, and such flagellate forms since 1911 have been recorded by several observers in man. As a result of experimental work, such as that of Patton and Wenyon, it has been shown that species of Leishmania can develop into herpetomonad flagellate forms within the intestines of certain insects, such as bed bugs (Cimex spp.) and mosquitos (Stegomyia). Recently, Mrs. Adie and Major Patton (1921-2) have produced evidence that an intracellular stage of Leishmania occurs in the intestinal cells of the bed bug, and appears to be an essential stage in the life-history. Both authors have given a number of illustrations of the parasites as found by them in their respective researches, and also have depicted forms found in the salivary

* Summarised in "Animal Parasites of Man," by Fantham, Stephens and Theobald, p. 80.

† *Arch. f. Schiffs u. Tropen Hygiene*, xxiii, pp. 211—226.

glands of the hosts. Mrs. Adie's work has since been criticised. However, Leishmania morphologically is a herpetomonad and behaves as such.

The origin of leishmaniasis in man and in dogs has been sought experimentally. Insects, both blood-sucking and non-blood-sucking, are known to harbour many species of Herpetomonas, that of the house fly, *Musca domestica*, known as *Herpetomonas muscæ domesticæ*, being the first recorded. Other Diptera, such as species of Sarcophaga, Lucilia, Stratiomyia, Culex, Melophagus; fleas such as *Pulex irritans, Ctenocephalus canis* and others; lice and many bugs, both bed bugs and plant bugs, all harbour herpetomonads. The life-histories of many herpetomonads in their insect hosts have been worked out by Patton, Fantham, Porter, Chatton, Laveran and Franchini, among others. The relation of such insect flagellates to vertebrates was elucidated by the independent experimental work of Laveran* and Franchini in France and of Fantham and Porter in England, whose researches in each case have extended over a long period. The results of these workers may now be summarised.

Laveran and Franchini, in their early work published in 1913, recorded infections of mice by the inoculation of *Herpetomonas ctenocephali* (from dog-fleas), while they have subsequently obtained similar infections in rats and mice by inoculating or feeding them with *H. pattoni* (from rat-fleas), and in dogs by inoculating them with *H. ctenocephali. Crithidia fasciculata* from *Anopheles maculipennis*, and *Crithidia melophagia* from *Melophagus ovinus* inoculated into white mice and rats have resulted in the infection of the vertebrates with the Crithidia of the insect,. the parasite being recovered from their blood and organs.

Mice were infected with *Crithidia fasciculata*, and one showed skin lesions on the neck. Dogs and monkeys inoculated from mice infected with the flea flagellates *Herpetomonas ctenocephali* and *H. pattoni* have also developed herpetomoniasis. Dogs have also been infected by inoculation of *H. phlebotomi* and guinea-pigs with *H. ctenocephali* White mice have been inoculated with *H. sarcophagæ* from *Sarcophaga hæmorrhoides*, and a recently-described new species of herpetomonad, *H. periplanetæ*, from *Blatta orientalis*, has also produced infection in mice.

An extraordinarily interesting result accrued in 1920, when the French workers succeeded in infecting the plants *Euphorbia sauliana* and *E. pilosa* with *Herpetomonas ctenocephali* from the dog-flea, many flagellates occurring in the latex of these plants as a result of the inoculation.

A converse experiment was also performed, latex of *Euphorbia nereifolia* containing a Herpetomonas being injected into white mice and producing infection in the same.

From the various figures published by Laveran and Franchini, it seems clear that the non-flagellate forms predominated in their

* See Treatise on "Leishmanioses," Paris, 1917.

experiments. Also, it will have been noted that the vertebrate hosts employed by them were solely confined to the Mammalia.

Fantham and Porter* (1914-16) worked with various herpetomonads different from those of the French authors, and also extended the range of their hosts, so that all classes of vertebrates were represented. The English authors also used natural modes of infection, such as feeding animals with insect flagellates, and further, they determined that the post-flagellate or non-flagellate forms of Herpetomonas and Crithidia were most effective as a means of producing infection in vertebrates. Also, vertebrates bred by the workers themselves in the laboratory were used in every case, and the possibilities of natural infection were thus excluded.

Thus, young white mice, *Mus musculus*, were infected by feeding them with *Herpetomonas jaculum* from the water-bug, *Nepa cinerea*, and by intraperitoneal injection of the same flagellate. Flagellate and non-flagellate herpetomonads were recovered from the vertebrates, and the infections were often of the acute type. White mice were also infected by feeding on the intestines of *Stratiomyia chameleon* and *S. potamida* containing *Herpetomonas stratiomyiæ;* also by feeding on lice intestines infected with *H. pediculi;* while, by administering the liver of a mouse infested with *H. pediculi* to another mouse, the infection was carried on. *Crithidia gerridis* from *Gerris paludum* fed to mice produced an infection, but intraperitoneal injection failed. Another mouse, injected with *C. gerridis*, showed both flagellate and non-flagellate forms in its blood and organs, and had a skin sore, not unlike oriental sore, and infected with Crithidia, at the site of inoculation.

Among birds, canaries (*Serinus canarius*) were infected by feeding on insects containing *Herpetomonas jaculum;* sparrows (*Passer domesticus*) by feeding with Culex containing *H. culicis;* martins (*Chelodon urbica*) by feeding with food contaminated with insect excrement containing *H. culicis;* the grass snake (*Tropidonotus natrix*) became infected with *H. jaculum*, which was fed to it; lizards (*Lacerta vivipara*) became infected with *Crithidia gerridis*, either by feeding on infected insects or by feeding on the livers of lizards originally infected by feeding, or by intraperitoneal injection of the heart blood of lizards thus infected.

Among Amphibia, frogs (*Rana temporaria*) were infected with *Crithidia gerridis* by the intraperitoneal route. Other frogs were infected with *Herpetomonas jaculum* by intraperitoneal and subcutaneous routes, and toads (*Bufo vulgaris*) by similar means were artificially infected with the same parasite.

Among fishes, sticklebacks (*Gasterosteus aculeatus*) were infected by subcutaneous inoculation of *Herpetomonas jaculum*.

Recently (1921) Fantham has succesfully inoculated *Herpetomonas muscæ domesticæ* into a white rat in Johannesburg, a herpetomoniasis of the fulminating type being produced for a short time, followed apparently by complete recovery of the rat.

*Summarised in *Journal of Parasitology*, ii, pp. 149—166.

Thus, in the words of the English authors (published in 1916): " No insect flagellate can be considered to be quite innocuous to vertebrates until it has been put to the test." By these experiments it was shown that the induced herpetomoniasis could run an acute or a chronic course. In the acute cases, the flagellate form of the parasite was the more obvious one found at death; in the chronic cases, the non-flagellate forms of the parasite were more numerous.

Under suitable conditions it is clear that insect flagellates can be introduced into vertebrate hosts and can produce infections therein. In some cases, as in the cold-blooded hosts, little obvious ill-effect results; in others, as in mammals and in birds, disease is manifested and often ends in death.

The flagellates introduced into vertebrates retain their powers of development on the same lines as when they are present in the insect. The various species of Leishmania are probably insect flagellates relatively long introduced into man and usually perpetuating the non-flagellate form, though capable of assuming the flagellate, herpetomonad facies in the internal organs of the vertebrate or in the invertebrate host.

Again, it is necessary to consider not part, but the whole, of the life-history of an organism, and also the relation of the parasite to the group to which it belongs. There is a line of evolution common to each group, and in the cases under consideration, Herpetomonas, Leishmania, Crithidia and Trypanosoma should be considered not as isolated units but as members of the Trypanosomidæ.

In connection with the Leishmania problem, one of the conclusions of the English workers* (1916) still holds and may be quoted: " In areas where leishmaniases are endemic an examination should be made of all insects and other invertebrates likely to come into contact with men or dogs or domestic vermin like rats and mice, in order to ascertain if these invertebrates harbour herpetomonads. Preventive measures should be directed against such invertebrates, especially Arthropods. Further, it is likely that members of all classes of vertebrates, and especially those members that are insectivorous, may serve as reservoirs for leishmaniases, or, as they should preferably be termed, herpetomoniases. The virus may exist in such reservoirs in a very attenuated condition and so be difficult of detection. From these sources the herpetomonads may reach man by the agency of ecto-parasites or flies, especially such as are sanguivorous."

Clou de Biskra.—In North Africa a form of Oriental sore known as " clou de Biskra," due to *Leishmania tropica*, occurs. In 1921 the insect transmitter was determined by Ed. and Et. Sergent, Parrot, Daratien and Beguet to be the sandfly, *Phlebotomus papatasii*. They reproduced the disease by crushing flies in saline solution and by vaccinating volunteers on the arm with the emulsion. A papule containing the non-flagellate or Leishman-Donovan bodies was thus produced. These experiments were

* *Journal of Parasitology*, ii, p. 164.

carried out in Algiers with flies sent from Biskra, for "clou de Biskra" does not occur in Algiers, and hence natural infection was excluded.

Aragão, in Brazil, carried out similar experiments with the local form of leishmaniasis, using dogs and the local sandfly, *Phlebotomus intermedius*. Infections were produced in this case also.

Species of Phlebotomus are thus now definitely incriminated as transmitters of Oriental sore, and preventive measures against such can be instituted.

Natural Herpetomoniasis of Vertebrates.

That some vertebrates exceptionally show infections with herpetomonad flagellates in nature is also known. Natural infections of mice with herpetomonads were recorded by Dutton and Todd in 1903 and by Fantham and Porter in 1915. The infection of pigeons with a herpetomonad was described by Ed. and Et. Sergent in Algeria in 1907. Geckos similarly infected were described by Sergent, Lemaire and Senevet in 1914, and by Chatton and Blanc in Tunis in 1918. Marcel Léger found herpetomonads in small lizards (*Anolis* sp.) in 1918 in Martinique. Herpetomonads have also been described from the blood of fish. infected *Dentex argyrozona* having been found at Cape Town in 1920 by Fantham and Porter.* Even in the human subject a herpetomonad, at first called *Hæmocystozoon brasiliense*, was found by Franchini in 1913.

Flagellates and Flagellosis of Plants.

The occurrence of flagellates in the latex of a plant, namely, *Euphorbia pilulifera*, was first reported in 1909 by David in Mauritius. Later, Lafont described the parasite from the latex of *Euphorbia thymifolia* and *E. hypericifolia*, naming it *Leptomonas* (*Herpetomonas*) *davidi*. Other workers have described the organism from species of Euphorbia in Africa, and Donovan in 1909 found it in Madras in plants growing in the grounds of a hospital. França† in 1914 gave a careful and detailed account of the morphology of the parasite, and then described in detail its effects on the host plants. The infected plants wilted, showed yellowish foliage that dried at the base and readily fell. Infected branches broke off easily or grew much more slowly than uninfected branches.

Lafont had shown that the bug, *Nysius euphorbiæ*, was able to transmit the disease from plant to plant. França at first was unable to find the transmitters in his cases, but later incriminated another bug, *Stenocephalus agilis*. Other workers have also discovered other insect transmitters of the herpetomonad. Some of the most recent work is by Laveran and Franchini, either working alone or in collaboration, and some of their results now cited were only published in May, 1922.

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* *Journal of Parasitology*, vii, pp. 16—22.
† *Arch. f. Protistenkunde*, xxxiv, pp. 108—132.

Herpetomonads (Leptomonads) have been found by Franchini* in the latex of various Euphorbiaceæ, Apocynaceæ, Urticaceæ and Sapotaceæ, and in one example of the Cruciferæ, the common cabbage. In this connection it may be of local interest to note that such flagellates have been found in cabbages in South Africa by Professor H. B. Fantham, who has also found Herpetomonads in South African soil. Franchini's infected cabbages were grown in France and Roubaud has also found similarly parasitised cabbage in other districts in France.

As previously mentioned, Laveran and Franchini have injected cultures of *Herpetomonas ctenocephali* into healthy *Euphorbia sauliana* and *E. pilosa*, producing flagellosis therein. The converse experiment was also successful, white mice inoculated with herpetomonad-containing latex of *Euphorbia nereifolia* contracting definite infections with the flagellate.

That plant flagellates can be infective to mammals is now proved. That it is no new idea is shown by the following quotation from a paper by Fantham, published in 1915.† He states: "Nearly three years ago I was informed by a competent authority that a number of Euphorbia containing Herpetomonads grew outside a certain hospital situated in an area in which kala-azar was endemic, and in which kala-azar patients were being treated. The shrubs were infested by insects. It seems remarkable that no attempt was made to trace a possible connection between the plant herpetomonad and kala-azar; doubtless such a possibility was considered too remote. Remarks of mine regarding a possible connection were received by my informant with polite incredulity, which is not surprising, since the wisdom of lecturing on Herpetomonas and Crithidia to students of tropical medicine has been questioned more than once."

The source of the plant-inhabiting Flagellata was investigated by Laveran and Franchini, who found that, in a number of plant-feeding bugs, chiefly members of the Pentatomidæ, Pyrrhocoridæ and Lygæidæ, flagellates were present in large numbers. The fæces of these insects were rich in flagellates and their non-flagellate stages, and leaves of the plant were contaminated by the fæces. Salivary gland and proboscis infections of some of these insects also occurred. Thus, two sources of plant-infection were possible. Plant tissues may be infected direct by the bite of an insect showing salivary gland or proboscis infection, or the surface may be injured by mechanical means, such as the winds or insect bites, and then soiled by flagellate-containing insect excrement. The organisms introduced into the latex find themselves in a medium rich in nourishment, and somewhat similar to that in their original insect host, and, being relatively plastic, adapt themselves to the new environment and become established as parasites of the plants.

Franchini has found trypanosomes in various members of the Euphorbiaceæ. They were always relatively few in number.

* See various papers in *Bull. Soc. Pathol. Exot.*, xv.

† *Annals Trop. Med. & Parasitol.*, ix, p. 341.

Crithidia have been reported from plants, especially from the Euphorbiaceæ.

It may be mentioned here that Protista other than Herpetomonads occur in plants. Thus, amœbæ, which, when quiescent, varied from 10μ to 20μ in diameter, have been found by Franchini in the latex of various members of the Euphorbiaceæ, Asclepiadaceæ, Apocynaceæ, Urticaceæ, Artiocarpeæ, and Sapotaceæ. The amœbæ are said to be numerous in the latex of Apocynaceæ. In some cases, injury to the host plants occurred, in others it was not obvious. The transmission of amœbæ from plant to plant is probably by the contaminative method, the infected fæces of an insect reaching wounded surfaces of plants.

Spirochætes also have been found by Laveran and Franchini in the latex of Euphorbiaceæ.

Intestinal Flagellates and Their Pathogenic Action in Diarrhœa.

During the Great War flagellates belonging to the genera Giardia (Lamblia), Trichomonas and Chilomastix were often found in routine fæcal examinations, especially of dysenterics. Difference of opinion has occurred as to whether these flagellates are pathogenic to man. It must be admitted that they are associated with certain cases of diarrhœa. In the writer's opinion, they are the causal agents of certain forms of enteritis, as cases were known to me personally in which they were the only possible pathogenic organisms present in the disordered intestines. Further, experimental work conducted jointly with Dr. Fantham* in 1916 showed that undoubtedly *Giardia* (*Lamblia*) *intestinalis* (sometimes called *G. enterica*) was pathogenic to clean laboratory animals (kittens and mice), and also that strains of human Giardia acquired from different sources (Gallipoli and Flanders) varied in virulence in laboratory animals. In South America Escomel 1919† has thoroughly established the pathogenicity of *Trichomonas hominis*, and modifications of his treatment for trichomoniasis have been successfully introduced in South Africa. In connection with experimental work, it must be remembered that one positive result is of more value than a number of negative ones, especially when conducted by persons of experience, who breed their own animals for experimental purposes and, consequently, always have "clean" animals at their command.

Species of Giardia (Lamblia), Trichomonas and Chilomastix occur in other animals, especially rodents. Several species of Giardia have been recorded which may prove ultimately to be varieties of one species. Rodents also may act as natural reservoirs of the species found in man. The flagellates, in their encysted or rounded forms, can pass unharmed and unchanged through the bodies of insects, such as flies and cockroaches, and remain infective to man. The insects thus act as mechanical transmitters and distributors of the flagellates.

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* *Brit. Med. Journal*, July 29, 1916, pp. 139—141.
† "La Tricomonosis intestinal," Lima, 1919.

Neuromotor Apparatus in the Protozoa.

Recently, work on motor organellæ has been published by C. A. Kofoid and his pupils, of the University of California. There is not very much that is actually new in this work, so far as Flagellates are concerned, for it is chiefly a matter of new or extended interpretation of previously described structures.

Thus, Kofoid* (1916) states that " the conditions of parasitic life in a denser, more viscous medium increase the difficulties of locomotion, and have resulted in the evolution of additional motor organelles, and the establishment of a highly differentiated, co-ordinated, neuromotor apparatus."

The neuromotor apparatus consists of extranuclear chromatic substances, especially the parabasal body in such a form as Giardia, and this body or bodies is a reservoir of substances closely related to the basal granule or so-called blepharoplast at the base of a flagellum.

It may be noted that the many-named body, called by the Germans the blepharoplast and by Woodcock the kinetonucleus in the Trypanosomidæ, is homologous with the parabasal bodies of Giardia, and has recently been further named the kinetoplast.

A neuromotor apparatus, part of which consists of a circum-œsophogeal ring, has also recently been described† for species of the ciliates, Balantidium, Euplotes and Diplodinium.

Sporozoa.

In connection with malaria and malarial parasites, the problem of relapses is one of interest and one that is still imperfectly understood. The work of Gaskell and Millar‡ (1920) on malignant tertian malaria in Macedonia sheds some light on the problem. These authors classified the cases of infection with *Plasmodium falciparum* into three groups: (1) True cerebral, (2) septicæmic, and (3) cardiac. In connection with the last-named form, which was evidenced by collapse, the heart muscle showed signs of fatty degeneration and fragmentation. Young trophozoites, popularly termed " rings " of *P. falciparum*, were found inside these heart muscle fibres, lying in the undifferentiated protoplasm around the nuclei of the cardiac muscle fibres. The authors express the opinion that cardiac muscle fibres may be a place where " the parasite may be stored up in quiescent periods between attacks."

Several new species of Eimeria have been described from human fæces during the war. The species have been created on differences of shape and size of the oöcysts, but, unfortunately, the life-histories of most of the new forms are not known.

As an appendage to the Protozoology section, mention may be made of recent work on the Spirochætes of yellow fever and infectious jaundice and on Rickettsia bodies.

Yellow Fever and Infectious Jaundice.

A great advance in knowledge of the causal agents of disease was made when Noguchi (1919) announced the finding of a spiro-

* Proc. Second Pan-American Scientific Congress.

† See University of California Publications in Zoology.

‡ *Quart. Journal Medicine*, xiii, pp. 381—426.

chæte, named by him *Leptospira icteroides*, and cultivated by him from cases of yellow fever. The morphology of the tiny spirochæte was described. The transmitter, *Stegomyia fasciata*, has long been known, owing to the devoted labours of Carroll, Lazar and Agramonte; the causal organism is now known, and the chain of evidence is complete.

Spirocæta icterohæmorragiæ, now known to be the agent of infectious jaundice, is present not only in man but in rats and mice, producing little ill-effects in the rodents. The spirochæte is present in the urine of the hosts, and from food or water contaminated with infected rodent and human urine, the organism reaches man.

Rickettsia Bodies.

Rickettsia bodies, belonging to the Chlamydozoa, are the causal agents of both trench fever and typhus, both of which are louse-borne diseases.

Trench fever was a great source of trouble during the Great War, the causative agent, until lately, being unknown. However, Rickettsia bodies have been found in lice fed on trench fever patients, and, according to Ledingham (1920) these Rickettsia bodies are agglutinated by immune serum obtained from animals immunised with the infective excrement of lice. On the other hand, trench fever Rickettsia were not agglutinated by the serum of animals immunised with the excrement of normal lice. This provides strong evidence for incriminating the minute Chlamydozoon, Rickettsia, as the agent of trench fever. It may be mentioned that, according to Swift, the virus of trench fever is present in the blood of the patient at some period of the illness, is often present in the urine, and sometimes in the sputum of the patient. It is also found in the excrement and bodies of practically all lice that have fed several times on trench fever patients, and occurs in such lice after a period of five to ten days after the infective feeds.

In typhus fever, *Rickettsia prowazeki*, which occurs in lice, and in the malpighian cells of the skin of an infected person, is the recognised causal agent.

There is not space to deal fully either with the Chlamydozoa or with the group of filter-passing bodies, some of which undoubtedly are associated with disease. The development of new technique for dealing with these bodies is in progress, but much work still needs to be done on these elusive organisms, some of which are found in the sea and in the soil. Shelley's remarks regarding " The Cloud " might, perhaps, be applied to them:

" I am the daughter of earth and water,
And the nursling of the sky:
I pass through the pores of the ocean and shores,
I change, but I cannot die."

Helminthology.

Much attention has been devoted to helminthology in recent years, and a number of interesting life cycles have been elucidated. Some of these may now be considered.

SCHISTOSOMIASIS.

Schistosomes have been known as parasites of man for many years, the earliest form to be recognised being *Schistosoma hæmatobium*, the casual agent of urinary bilharziasis. However, the first life-history of a schistosome to be worked out was that of the Asiatic schistosome, *S. japonicum*. The adult worm was described by Katsurada in 1904. Its life-history was described by Miyairi and Sudzuki in 1914. These workers found dark-shelled snails, *Blanfordia nosophora*, containing cercariæ. They obtained specimens of the uninfected snails and exposed them to miracidia of *S. japonicum*, and traced the stages of their development into cercariæ like those found in nature in the snails. Mice were immersed in the water in which the snails were kept, and adult *Schistosoma japonicum* were found in them after a few weeks. In 1914 Leiper confirmed this work in Japan. In 1916 Narabayashi showed that man, cattle, horses, pigs, goats and dogs could all become infected naturally with *S. japonicum*.

The ova of *S. japonicum* are non-operculate, oval, with a very small lateral spine or thickening that often is not noticed at all, or may not be present, and a cap-like thickening at the opposite end. The miracidium hatches rapidly, swims in the water, and further development takes place when it reaches the snail, *Blanfordia nosophora*. Sporocysts are formed which produce cercariæ. Each cercaria is an elongated oval body, with short lancet-shaped bristles at the mouth. There is a small ventral sucker. Three pairs of mucin glands are present, their ducts opening into the mouth. The excretory system has been worked out chiefly by Faust, and is rather simpler than that of *S. hæmatobium*.

Narabayashi has shown that the cercariæ penetrate the skin of the vertebrate host and pass into the venous system. Thence they reach the heart, pass through the lungs, and thence migrate through the diaphragm and liver into the portal system, whence, after attaining sexual maturity, they migrate into the mesenteric, vesical and other veins.

The adult male, *S. japonicum*, is 8mm. to 19mm. long, and possesses six to eight testes in the anterior of the body. The cuticle of the male, unlike that of *S. hæmatobium* and *S. mansoni*, is relatively smooth, with only a few spines and no marked bosses. The female is from 8 mm. to 26 mm. long. The suckers possess fine spines. As in the male, the intestine forks far back, and the single portion of the intestine is small.

Schistosoma hæmatobium is widely distributed in Africa and also occurs in other parts of the world. For instance, it has recently been imported into Australia by soldiers who contracted the infection in Egypt, where the disease is extremely prevalent. Cases also occur in South America, but are relatively few. In Europe, through the agency of returned soldiers, molluscan infection has occurred, and new cases have arisen in Portugal.

During the war, when there were many troops in the Eastern war zone, bilharziasis caused much trouble in Egypt. Leiper* (1915) investigated the transmitters, and worked out that the carrier of *Schistosoma mansoni* in Egypt, where there was bil-

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harzial dysentery, was the common snail, *Planorbis boissyi*. In the case of *S. hæmatobium*, the agent of urinary bilharziasis, four snails were incriminated, namely, *Bullinus contortus*, *B. dybowski*, *B alexandrina* and *B. innesi*, the infection of the latter being rare. The minute morphology of the stages of the cercariæ in the snails was not worked out, but has since been ascertained by Faust and by Porter. One transmitter of *S. hæmatobium* in South Africa was first experimentally determined in Johannesburg by Dr. J. G. Becker at the Institute for Medical Research, and this was confirmed by Cawston and by Porter. The structure and life-history of these human flukes may now be briefly considered.

Schistosoma hæmatobium in South Africa is transmitted chiefly by *Physopsis africana*, and occasionally by *Limnæa natalensis*.* The terminal spined ova pass from the human body with the urine. If they reach water, a ciliated larva or miracidium hatches from each egg and swims about. If *Physopsis africana*, or more rarely *Limnæa natalensis*, is encountered, the miracidia penetrate the pulmonary cavity of the snail, enter the liver and develop into sporocysts. From the walls of the sporocysts buds arise which develop into bifid-tailed cercariæ. The cercaria of *S. hæmatobium* has a body about 240μ long by 100μ broad, its tail is about 200μ long by 45μ broad, the caudal forks being from 80μ to 100μ long. Both the oral and the ventral sucker or acetabulum are small. Three pairs of mucin glands are present, each capped by a hollow, piercing spine, and opening on the outer margin of the oral sucker. A group of several large germ cells lies behind the posterior sucker.

The cercariæ eventually leave the snail and swim about freely. Should they come in contact with the skin of a person bathing or paddling in the water, or even drinking it, they attach themselves by their suckers to the skin and bore through it, dropping their tails as they do so. They reach the blood vessels and ultimately find their way to the liver and mesentery of the human host, in the blood vessels of which sexual maturity is attained. The adult worms in many cases make their way to the bladder, in the veins of which oviposition occurs.

The adult *S. hæmatobium* are unisexual, the males being broader and thicker but shorter than the females. The males that I have obtained experimentally have varied from 3mm. to 17mm. in length. The suckers are near one another, the central one being the larger and being pedunculated. The surface of the body is beset with cuticular spines. The œsophagus passes into the intestine which bifurcates behind the posterior sucker. The cæcal forks reunite far back, and the gut ends as a single canal of short length. There are four large, rounded testes. The edges of the body are folded to form the characteristic gynæcophoric canal. The females obtained experimentally by me varied from 5mm. to 30mm. long. They were threadlike, with weak suckers. In each the ovary is in the posterior half of the body, the uterus is voluminous and usually contains a number of mature terminal spined eggs at one time. The vitellaria lie in the posterior quarter of the body. The female is carried in the gynæcorphoric canal of the male. The eggs are deposited in the walls of the bladder, whence they make their way to the cavity of the bladder and pass out with the urine.

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* *Medical Journal of South Africa*, xv, pp. 128—133.

Schistosoma mansoni, the excitant of bilharzial dysentery, is transmitted in South Africa—as I* have shown experimentally—by at least three molluscs, namely, *Planorbis pfeifferi, Physopsis africana* and *Isidora tropica*. *Schistosoma mansoni* is not a common parasite of man in the Union of South Africa, but is fairly common in British and Portuguese East Africa, and very common in South America. My infected molluscs were collected in Natal. *Planorbis pfeifferi*, in my opinion, is probably the most common transmitter of *S. mansoni* and *Isidora tropica* the least common. In South America, Iturbe and Gonzalez have proved that *Planorbis guadaloupensis* is the commonest molluscan host for the fluke.

The life-history of *Schistosoma mansoni* is on the same lines as that of *S. hæmatobium*. The ova are lateral spined. The miracidia are liberated in water and if successful in reaching one of the molluscs mentioned, sporocysts and then cercariæ are produced. These cercariæ are smaller than those of *S. hæmatobium*, the body of each being about 150μ long and 60μ broad, the tail being proportionately smaller. The body contains two pairs of large, acidophile mucin glands and four pairs of smaller basophile mucin glands. Each gland opens by a hollow spine at the anterior end of the oral sucker. The rudiments of the genitalia consist of numerous small cells. The cercariæ leave the snail and penetrate the skin of persons exposed to the water containing them as in the case of *S. hæmatobium*.

The adult male differs from that of *S. hæmatobium* in that it has eight small testes, while its alimentary canal has forks that unite after a relatively short distance, the single portion of the intestine hence being long. The males that I have obtained experimentally were from 3mm. to 11 mm. long, while the filiform females were from 4mm. to 14mm. long. In the female the ovary is median, the vitellaria occur in the posterior part of the body, and the uterus usually contains one only of the lateral-spined ova at a time. The ova are laid singly in the submucosa of the rectum, whither the females migrate, and cause ulceration there. The eggs pass out of the fæces of the infected persons. The dysentery produced is of a very intractable type.

Preventive measures against infection with *Schistosoma hæmatobium* and *S. mansoni* may be briefly summarised. Measures against pollution of soil, and especially of water, by urine and fæces of infected persons must be instituted—proper disposal of excrement, preferably by incineration, is necessary. Great care is needed to prevent water contamination and infection of water-snails. The destruction or reduction of the molluscan population can be brought about to a large extent by the introduction of domesticated ducks. As the cercariæ die after a period of about two days, allowing water to stand for at least two days before use will permit of the death of the cercariae. Dr. Cawston has found that small fish of the "millions" type will feed on cercariæ as well as on mosquito larvæ, and hence serve a dual purpose in sheets of water into which they have been introduced.

The successful treatment of bilharziasis by intravenous injections of tartar emetic was first set forth by Dr. J. B.

* *Medical Journal of South Africa*, xvi, pp. 75—76.

Christopherson in Khartoum, and has since been successfully practised in almost all areas where bilharziasis is endemic.

Clonorchiasis.

The Chinese liver fluke, *Clonorchis sinensis*, has been known as a parasite of man since 1875, when the adult form was described by Cobbold. The life-history of the worm has, however, only been elucidated relatively recently by the experimental work of several Japanese scientists. Clonorchiasis is known to occur in China, Formosa and Japan, and cases have been reported in Chinese subjects from many parts of the world. Recently (May, 1922) a case occurred in Johannesburg.*

The adult fluke varies from 10mm. to 17mm. long, and is about 3mm. broad. It is thin and delicate looking, and is found in the liver and gall bladder of man, and also of cats, dogs, pigs and rats in the East. Some interesting points in its morphology may be mentioned. The body contains numerous densely-packed yellowish-brown granules, which, according to Kobayashi, are derived from the yolk. The simple intestine forks just below the oral sucker, the cæca extending almost to the posterior end of the body. There is a large S-shaped excretory bladder dorsal to the testes. Its two main contributory channels originate near the point of forking of the intestine and open into the bladder near its anterior end. The excretory pore is median and terminal.

The anterior testis usually has four branches, and the posterior testis five. The ovary usually has three large and one small lobe. The vitellaria or yolk glands are situated laterally, and extend from the ventral sucker nearly to the posterior end of the body. They may or may not be discontinuous, this depending on the age and stage of growth of the parasite.

The ova are about 24μ to 30μ long, and are about 16μ broad. The operculum is very distinct, and has been compared with the lid of a teapot.

The life-history of Clonorchis is of considerable interest. The immediate source of infection of the higher vertebrates such as man, dog and cat, was worked out by Kobayashi† in 1911. He found that certain freshwater fishes belonging to the Cyprinidæ (carp and roach family) acted as second intermediate hosts, harbouring encysted cercariæ on their gills and in their livers and musculature. By administering such cysts in raw fish to normal, healthy kittens, adult Clonorchis were produced. The principal infected fish were *Pseudorasbora parva*, *Leucogobio guntheri*, *Leucogobio mayedae* and *Carassius auratus*. Other fish infected to a lesser extent were *Acheilognathus lanceolatus*, *A. limbata*, *A. cyanostigma*, *Paracheilognathus rhombus*, *Pseudoperilampus typus*, *Abbottina psegma*, *Buwia zezera*, and *Sarcocheilichthys variegatus*. The Clonorchis cysts are oval, the largest being about 135μ to 145μ by 90μ to 100μ. The larva within is bent on itself, and at an early stage of encystment still has eyespots. In a fairly old cyst, rudiments of all the adult organs can be detected, while the ventral sucker is more pronounced than the oral, but this relation is reversed in the adult condition. Young encysted flukes have spines in their cuticle, and these grow larger when the young fluke emerges from its cyst in its final host. Gradually, however, the spines are lost, and specimens obtained from experimental cats 23 days after the infective feed are the oldest known to possess spines.

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* See *Medical Journal of South Africa*, xvii, pp. 240—244.

† For accounts of Japanese literature see reviews in the *Tropical Diseases Bulletin* and in the *China Medical Journal*.

Kobayashi worked out the development of Clonorchis day by day in infected cats and gave a most valuable account. The infected piscine hosts were those used for food in Japan, and by experiments he determined that the usual modes of cooking the fish, such as short boiling or roasting, or merely soaking in vinegar and soy sauce (a common method of preparation) do not kill the cysts.

The source of infection of the various fishes was not determined till 1918, when a paper by M. Muto appeared. He investigated the trematode parasites of various molluscs and fish in Japan. In the mollusc, *Bithynia striatula* var. *japonica*, sporocysts were found that gave rise to cercariæ that encysted in the fish, *Pseudorasbora parva*. The fish thus infected were fed to dogs and mice and adult *Clonorchis sinensis* produced. Muto went further. He infected some Bithynia with miracidia hatched from the eggs of *Clonorchis sinensis* and obtained sporocysts and cercariæ identical with those found in nature, the sporocysts being produced about three weeks after exposure of the snails to the miracidia.

The life-history, then, is complete. Ova of Clonorchis are passed with the fæces of infected persons or animals. If they reach water the miracidia escape, and should they reach the water snail, *Bithynia striatula*, they penetrate and develop into sporocysts in about three weeks. From the sporocysts cercariæ are produced that encyst on the gills or in the muscles and liver of certain Cyprinidæ. The cysts, consumed with raw fish, in the fresh or dried condition, develop into *Clonorchis sinensis* in man, dog, cat, pig and rat. About 26 days after ingestion of the cysts, ova of the flukes appear in the fæces of the final host.

It may be mentioned that Muto has found that about 50 per cent. of the rats in infected districts in Japan harboured *Clonorchis sinensis*.

Formerly two species of Clonorchis were differentiated, *C. sinensis* and *C. endemicus*. Kobayashi has now shown that the two supposed species are but age and growth variations of *Clonorchis sinensis*, and the species *C. endemicus* disappears.

It has been found in the United States that a large proportion of the Chinese entering the country are infected with Clonorchis. Thus, in 1916, of 604 Chinese immigrants arriving at San Francisco, Gunn found that 125 harboured the parasite.

The molluscan hosts are species of Bithynia, which is very widespread and is found in China, Japan, Indo-China, Dutch East Indies, Africa and Southern Europe. Members of the Cyprinidæ are also practically cosmopolitan. There is thus a possibility of Clonorchis establishing itself in South Africa, while the importation of Chinese fish by the Chinese for their own consumption (as occurs in South Africa) provides another source of infection.

It is of interest to note that a number of cases of Clonorchis infection associated with carcinoma of the liver have been recorded, including the recent case in Johannesburg.

Paragonimiasis.

The lung fluke, *Paragonimus westermani*, is the cause of human pulmonary distomiasis accompanied by hæmoptysis in the East, and has been reported from North America and from South America.

Paragonimus westermani is a small, somewhat oval fluke, varying from 8mm. to 16mm. in length, by 4mm. to 8mm. broad, and 3mm. to 4mm. thick. Its colour is reddish brown. The whole cuticle is covered with scale-like movable spines. The oral sucker is spherical and terminal, very slightly smaller than the acetabulum. The alimentary canal consists of a short œsophagus which branches into two sinuous cæca. The small genital orifice opens near the margin of the ventral sucker. There are two testes, arranged laterally, one slightly anterior to the other, lying just behind the branched uterus. The ovary is opposite and slightly posterior to the uterus. The yolk glands are lateral and almost meet dorsally, but on the ventral side they only extend as far as the intestinal cæca. The excretory system is well developed, and extends from the pharynx backwards.

The life history of Paragonimus has been worked out mainly by Japanese investigators, chief among whom may be mentioned Nakagawa, Kobayashi and Sadao Yoshida. It may be mentioned that Nakagawa and Yoshida worked independently of each other, but published their results about the same time, and that each worker came to the same conclusions.

It was ascertained and published about 1916 that the encysted stages of *Paragonimus westermani* had been found in certain river crabs. By feeding laboratory animals such as rats and cats with these crabs, adult Paragonimus were obtained. Nakagawa (1916) in Formosa found that the "red" crab, *Geothelphusa* (*Potamon*) *obtusipes* Simpson, the "dung" crab *Geothelphusa* (*Potamon*) *dehaanii* White, and the "hairy" or "fur" crab, *Eriocheir japonicus* de Haan, were the hosts of the encysted cercariæ of *P. westermani*. Kobayashi has found that *Astacus japonicus* also harbours the agamodistomes in certain parts of Korea. Fresh raw crab is used by the Koreans as an antipyretic and diarrhoea remedy.

In these Crustacea, the encysted larval flukes occur in the liver, the muscles and the gills. The thickwalled cysts are rounded to oval, and measure about 0·3 mm. to 0·4 mm. in diameter. The larva has a short, thick body, and lies straight, not twisted, in the cyst. The body is covered with short spines. The oral sucker is about 0·08 mm. to 0·11 mm. in diameter, the ventral sucker being 0·07 mm. to 0·12 mm. in diameter. The short œsphagus leads to a bifurcate, thick, undulating intestine that lies parallel to the long, thick, excretory vesicle.

Nakagawa (1916) found that in Formosa the primary hosts of the lung fluke were the snails *Melania libertina* and *M. obliquegranosa*. Kobayashi (1919) found that in Korea *Melania paucicincta* and *M. gottschei* harboured the cercariæ. He also has bred the cercariæ from the miracidia in these snails.

The miracidia, on being liberated in water from ova contained in sputum, penetrate species of Melania and each develops beneath the skin of the snail into a sporocyst, within which a redia is produced. This redia migrates into the liver of the snail,

where a second redia is produced. Within this redia several cercariæ are formed, but one only matures, which may become free-swimming. The free cercariæ are 0·12 mm. long and 0·09 mm. wide. The tail is about 0·054 mm. long. The oral sucker has two pear-shaped bodies attached to it. It also bears spines, each with a ringlike border. The ventral sucker is much smaller than the oral, being about 0·018 mm. in diameter. Three pairs of mucin (or poison) glands are present, and there is a heart-shaped excretory vesicle. When the free cercariæ attack the gills, muscles or liver of the crustacean host, or perhaps the snail containing cercariæ is devoured by a crustacean, the cercariæ encyst. The flesh of the Crustacea eaten in a raw or imperfectly cooked condition is the source of infection for mammals, including man.

The process of encystment and maturing takes about 30 days. The encysted cercariæ are long lived, and Kobayashi has found that they can live as long as six years in crabs and then infect experimental vertebrates. When the cysts reach the intestine of the final host, the flukes emerge, pass through the intestine into the abdominal cavity, wander towards the diaphragm, pierce it and thus reach the pleural cavity and the lungs. Extensive damage may be done during the migrations of the flukes, which attain full maturity in the lungs. The early stages of human infection are often considered the most harmful, the symptoms resembling those of pneumonia.

Vertebrate hosts of Paragonimus other than man are known. Dogs, cats and pigs are known to be infected in Japan and Formosa, as was shown by Nakagawa and by Kobayashi. Onji (1921) has found the parasite in the fæces of weasels and "racoon dogs" in Japan. He believes that several other crab-eating animals such as otters, bears, boars and monkeys are probably also natural hosts, and that ova passed with the fæces of these animals serve to infect the snails. He also thinks that an additional source of human infection is by swallowing cysts from dead crabs in drinking water.

Paragonimus originally was confined to the Far East. Now it has spread to South America, and particularly has increased in Peru of recent years, owing to the immigration especially of Japanese and some Chinese sufferers, and the occurrence in Peru of suitable invertebrate hosts. In 1910 the first case was demonstrated in a Peruvian who had charge of a gang of Japanese coolies, and the number of cases of Peruvians has increased rapidly since then, the disease having become endemic. It has also spread to North America. The occurrence of suitable native Mollusca and Crustacea, as well as the importation of molluscs from infected areas, coupled with the occurrence of a human reservoir, may result in the introduction of such diseases as paragonimiasis and clonorchiasis in any country.

Metagonimiasis.

Metagonimus yokogawai, Katsurada, 1913, is a small fluke occurring in the adult condition in the upper and middle part of the jejunum of man, cat and dog, where they enter and destroy

the glands. Many workers have reported them from Japan proper, Yokogawa found them in Formosa and Muto in Korea.

The small adult fluke varies from 1·5 mm. to 4·5 mm. long, and is from 0·4 to 0·7 mm. broad. The body is covered with nail-like spines, about 10μ long. The oral sucker is from 75μ to 85μ in diameter, and the acetabulum is characteristic, being a sac-like organ situated deep in the body and not opening on to the ventral surface. The testes are elliptical, situated laterally near the posterior end of the body, one slightly anterior to the other. The vesicula seminalis is retort-shaped, and lies transversely, internal to the ventral sucker. The genital sinus receives the openings of the ejaculatory duct and uterus, and opens into a genital pit at the front of the ventral sucker. The ovary is spherical. The vitellaria consist of about 10 acini on each side of the body, and the shell gland lies to the left of the ovary. The uterus forms 3 to 4 large, transverse coils. The eggs are yellowish brown and elliptical, and have no "shoulder" below the operculum as occurs in Clonorchis. They are about 28μ by 16μ.

The life-history has been elucidated chiefly by the work of Yokogawa (1915) and Muto (1917), and its broad outlines resemble those of *Clonorchis sinensis*.

The hosts whence Metagonimus gains access to man consist of a trout, *Plecoglossus altivelis*, and various other freshwater fish, chiefly belonging to the Cyprinidæ. The encysted cercariæ occur beneath the scales and near the fins and tail. Kittens fed on infected fish passed Metagonimus eggs in their fæces in 12 to 15 days after eating the fish. Muto in 1917 published his account of the source of infection of the fish. He investigated many molluscs in Korea and found that from 2 to 50 per cent. of those examined harboured cercariæ of Metagonimus, the percentage varying with the locality. *Melania libertina* is the chief infected mollusc, in which sporocysts, rediæ and cercariæ are produced. Full details and experimntal evidence are given by Muto.

The mode of infection of man is by eating infected fish in a raw or imperfectly cooked condition. According to Yokogawa, the trout, *Plecoglossus altivelis*, is a delicacy eaten raw by the Japanese, and his own assistant, who frequently ate raw trout, contracted infection with Metagonimus therefrom.

Some Other Fluke Infections.

Recent advances in our knowledge of a number of other flukes have been made, but time does not permit of more than a bare note made of them.

Recently (1921) Nakagawa* has published an account of his researches on the life-cycle of *Fasciolopsis buski*. This fluke, which may attain the great length of 70 mm., is a parasite of man and of pigs in India, Assam, Siam, China and Cochin-China (among Annamese), and of pigs in Formosa. The eggs hatch in summer, and the miracidia have been proved experimentally to penetrate *Planorbis cœnosus*, *Segmentina largillierti*, *Planorbis compressus* and *Limnæa pervia*. The miracidia develop into sporocysts which produce rediæ about 7 days after exposure to

* An accessible account will be found in *Journal of Parasitology*, viii, pp. 161—166.

infection. In about 10 days, the rediæ reach the livers of the snails, and are then about 0·5 mm. long. After about 35 days, daughter rediæ and cercariæ are produced. Each redia contains from four to seven cercariæ, which are simple-tailed, have a body measuring 0·21 mm. to 0·23 mm. long and from 0·1 mm. to 0·15 mm. broad. The oral sucker is slightly larger than the ventral. The cercariæ leave the water ultimately and encyst on vegetation, forming a somewhat flattened disc-shaped cyst. When such cysts were fed to clean pigs fully grown specimens of Fasciolopsis were found at the autopsy.

Several species of Fasciolopsis have been described, and opinions differ considerably as to whether all the species are valid. Ward considers that *F. buski*, *F. rathousi*, *F. fulleborni* and *F. goddardi* are distinct species, basing the species on differences in the spines of the cirrus sac. Odhner, on the other hand, considers that the various species should be merged into one.

The interesting small fluke, *Heterophyes heterophyes* is known as a parasite of man in Egypt, Anglo-Egyptian Sudan, and China. It also occurs in cats and dogs in these countries. In 1915, Onji and Nishio described a second species, *H. nocens*, from man. So far, it has only been reported from the south-west part of the largest of the Japanese islands, but between 20 per cent. and 30 per cent. of the inhabitants are infected. *Heterophyes nocens* resembles *H. heterophyes*, but is even smaller, being only 0·9 mm. to 1·1 mm. long. Its extra genital sucker has some 60 rodlets, while *H. heterophyes* has from 60 to 75. Infection is contracted by eating the raw flesh of the fish *Mugil japonicus*, in which encysted larvæ of the fluke occur. The source of infection of the fish is unknown. When clean dogs are fed on infected *Mugil capito* (a " harder ') eggs of the fluke appear in the fæces 7 to 8 days after the infective feed, so that the development of the parasite in the vertebrate host is rapid.

Echinostomes in man have been known for some time. Thus, *Echinostoma ilocanum* was reported from the intestine of Filipinos in 1908 and *E. malayanum* from the intestine of Malays in 1911. The life-history of the human fluke remained unknown till it was recently worked out by Ciurea in Roumania on *Echinochasmus perfoliatus*, though it is of interest to recall that one of the earliest Trematode life-histories to be worked out was that of the Echinostome of the duck. Ciurea fed clean cats and dogs on various cyst-infected Danube fishes, such as *Idus idus*, *Tinca tinca*, *Scardinius erythrophthalmus*, *Abramis abramis*, *Esox lucius*, *Aspius aspius* and *Blicca bjorkna*, and found adult *Echinochasmus perfoliatus* in them. The encysted larvae occurred in the fish only along the lateral line. They were minute, being only about 0·197 mm. long and 0·147 mm. broad. Some of the encysted larvae were covered with fine spines. The oral sucker was slightly larger than the ventral adoral disc, which bore a series of 27 spines. The molluscan or other first host in which the parthenita and cercariæ are produced is not yet known. Ciurea believed that infection of man with *Echinostoma ilocanum* and *E. malayanum* is probably due to eating raw infected fish.

In South Africa, I have been able to work out the life-history of a bird Echinostome, provisionally named *Echinostoma fulicæ*, parasitic in the adult stage in the red-knobbed coot, *Fulica cristata*. This Trematode was described in some detail last year, and I now just mention that the larval stages are passed in either of the snails, *Isidora tropica* or *Tomisia ventricosa*. The cercariæ have a simple tail, with a pegtop-like terminal portion. Encystment takes place on the outside edge of the mantle, in the liver and on the outside shell of the snail. These snails are devoured by the coot and the adult develops in the intestine of the birds.

Recently, Dr. Cort has drawn attention to a report by Dr. Tanabe of the occurrence of *Echinostoma perfoliatum* var. *japonicum* in man, and of the outlines of its life-cycle being established. Tanabe fed clean dogs with encysted echinostomes found in certain fresh-water fish (of which the kinds are not given in Cort's notice), and as a result he obtained adult flukes from the dogs. Later, he found eggs of an echinostome in human fæces, and surmised that they came from the same kind of worms that he had produced experimentally. He then ate some of the cysts from the fish and produced the flukes in himself, thus proving that the cyst-bearing fish were the second intermediate hosts of *Echinostoma perfoliatum* var. *japonicum*.

The life-history of the cattle and sheep fluke, *Fasciola hepatica*, was worked out by Thomas and by Leuckart in classical researches published in 1882-3. In Europe the intermediate host is *Limnæa truncatula;* in South Africa, I have been able to prove that the molluscan hosts of the fluke are *Limnæa natalensis* and *Isidora tropica*.* The first-mentioned snail is also the South African transmitter of *Fasciola gigantica*,† as I have experimentally shown.

That man may become infected with *Fasciola hepatica* and *F. gigantica* is, perhaps, not so well known, but a number of cases of infection with *Fasciola hepatica* have recently been reported. Senevet (1920) records a case in a French soldier, who had served in the Dardanelles, Mudros and Salonika. De Lavergne had a case in an invalided French soldier. Mauriac and Boyer (1921) tried to treat a patient infected with *Fasciola hepatica* with tartar emetic, but their patient—and also some infected sheep treated at the same time—made no improvement, and death ensued. Guiart also reports a case of infection in a French soldier, who contracted the infection in Salonika. In all probability the eating of green salads or uncooked fruit or vegetables on which encysted flukes occurred was responsible for this intractable human infection.

Ancylostomiasis.

Among the Nematodes, there are a number whose life-histories have been known for some years. Thus, in the cases of *Ancylostoma duodenale* and *Necator americana*, their life-histories having been elucidated, attention has been focussed on

* *South African Journal of Science*, xviii, p. 159.
† Ibid., xvii, pp. 126—130.

preventive measures against ancylostomiasis and on more effective treatment of it. The great activities of the Rockefeller Institute in its hookworm campaign are well known and have extended to practically every country where hookworms are present. The reduction in tropical anæmia as a result of this campaign has been great, and better sanitation, aided by the intensive use of thymol in infected areas, has largely conquered the malady.

Ascariasis.

Another source of ill to man and beast is the round worm, Ascaris. The form infecting man is the large round worm, *Ascaris lumbricoides;* the pig-infesting form is *A. suilla*. Great interest attaches to the larval development and mode of infection of the host of these species. Most of the results have accrued from the work of Stewart* (1916-18), which has been repeated and confirmed by many workers in Europe, America and Japan. Until recently it was believed that an invertebrate intermediate host was necessary for Ascaris. Such is not the case, infection occurring by direct ingestion of ova. Stewart found that ripe ova gave better results in experimental animals than freshly shed ones. He also determined that the larvae performed an extensive migration in the body of the vertebrate host and did not pass their whole life in the intestine. The larvae hatch from the ova in the small intestine. They are fragile, but they bore their way through the mucosa, and, by way of the blood stream, reach the liver. From the liver they migrate to the lungs, where they remain for about 8 days. They then pass into the trachea, and on about the ninth day, some begin to migrate back to the intestine, though others persist in the lungs for as much as 15 days. By the tenth day, migration is fully established, and the larvae pass rapidly through the stomach and small intestine, to establish themselves in the cæcum and upper colon. The passage of the larvae through the lungs is attended by bronchitic symptoms, and " verminous bronchitis " is due to Ascaris as well as to other causes. *Ascaris suilla*, according to Stewart, undoubtedly causes an Ascaris pneumonia in pigs. He also states that there is " reason for supposing that a great deal of the debility of the natives of the tropics is due to ascariasis, and that this disease is at least equal to ancylostomiasis in economic importance." Yoshida, working on ascariasis in Japan, found that the lungs of infected animals show notable hæmorrhages and frequently pneumonic reactions, the severity being proportional to the degree and duration of infestation.

In South Africa, *Ascaris lumbricoides* is almost the commonest round worm of natives. *Ascaris suilla* occurs in a large proportion of pigs and sometimes in man. The transference of the ova of these parasites to man by way of dust contaminated with infected fæces and by flies is undoubtedly a source of danger, and has afforded an explanation of some bronchitic symptoms in certain children, for which no adequate cause could be assigned.

* See *Parasitology*, ix, x.

Strongyloides Infections.

Strongyloides stercoralis or *intestinalis*, as is well known, has a complicated life-history somewhat resembling that of Ancylostoma or Necator. The adult worms are small, being about 2·2 mm. long. A summary of its life-history is as follows:—A form occurs in the human intestine which is asexual and gives rise parthenogenetically to eggs. The eggs hatch sometimes in men, but more often extracorporeally, into the first rhabditiform larvae. At a temperature from 15°C. to 18°C., after a first moult, the rhabditiform larvae become strongyloid larvae. If, however, the temperature is raised from 20°C to 25°C., the rhabditiform larvae develop into definite free-living males and females. These mate, and the female then lays eggs that develop into the second rhabditiform larvae. After a moult these larvae become strongyloid or filariform, penetrate into the skin or enter the vertebrate host by way of the mouth, and eventually become the asexual intestinal form with which the story of the life-cycle commenced.

Recently some most interesting results have accrued from work by Brumpt* in connection with *Strongyloides papillosus* of sheep, which can also develop in the rabbit. Brumpt (1921) has found that in the sheep the parthenogenetic worm gives rise to eggs which develop in the proportion of 2,000 females to 1 male, and yield from 200 to 100,000 larvae by direct development. On the other hand, when the infection is produced in rabbits, the asexual or parthenogenetic worm gives rise to sexual worms in the proportion of 237 males to 409 fertile females, and yields 1,236 larvae by direct development. This striking contrast is attributable, perhaps, to the environments—that is, to the influence of the hosts.

Arthropods as Transmitters of Disease.

The study of Arthropods in connection with disease is an enormous subject. The relation of insects and ticks to disease has already been discussed in former Addresses delivered before this Association, and such ground need not be traversed again. It will suffice to give outlines of a few interesting items, some entomological, some dealing with Arachnids.

That the housefly, *Musca domestica*, is a pest to man by transmitting typhoid bacilli, tuberculosis, cysts of *Entamœba histolytica*, *Giardia* (*Lamblia*) *intestinalis* and other Protozoa is well recognised. A new way in which the housefly affects man and his stock has recently been shown by L. B. Bull† in Australia. This worker finds that *Musca domestica* acts as the intermediate host of species of Habronema, a Nematode whose larvae cause a granulomatous condition of the external mucous membranes of horses in South Australia, while the adult worms are parasitic in the intestines of horses. The larvae reach the horse by way of the housefly and destroy the skin and submucosa. The suggested remedies are to destroy all adult worms found, and

* *C. R. Soc. Biol.*, lxxxv. pp. 149—152.

† *Trans. Royal Soc. S. Australia.* xliii. pp. 85—131.

to destroy stable manure, at the same time preventing the access to manure of the necessary intermediate host, the housefly.

Stomoxys sp. has recently been shown by Ed. Sergent and A. Donatien to be the transmitter of camel trypanosomiasis in North Africa. According to these workers, the Stomoxys acts as a mechanical transmitter only, and infection occurs only when a fly attacks a healthy camel immediately after feeding on an infected one. This fact of mechanical transmission of the trypanosome of the camel has been proved experimentally, and perhaps explains the relatively small numbers of infected camels encountered.

The bug, *Conorhinus megistus* (perhaps more correctly called *Triatoma megista*), has been known for many years as the carrier of *Trypanosoma cruzi* in Brazilian trypanosomiasis. The disease has been reported from various parts of Venezuela, where, however, Conorhinus does not occur. In 1919, the Venezuelan transmitter was discovered by E. Tejara to be the bug, *Rhodnius prolixus*.

One practical development of entomology may be briefly noted. It is the use that is being made of hyperparasitism of insects. Much attention has been concentrated on the natural enemies of injurious insects with a view to utilising natural means for the extirpation of noxious pests or the prevention of their undue multiplication. Recently, T. H. Johnston has been working on Chalcid and other flies in Australia. He finds that *Spalangia muscidarum*, *Nasonia brevicornis*, *Pachycrepoideus dubius* and the Chalcids, *Chalcis calliphoræ* and *Dirhinus sarcophagæ* are prevalent. He has worked out the life-histories of the two first-mentioned, and their methods of parasitising bush flies. He has suggested that certain hyperparasites should be introduced into Australia, the chief being *Alysia manducator* and *Aphæreta cephalotes*, for the purpose of parasitising and thereby destroying noxious insects. The introduction of the Chalcid, *Melittobia acasta*, was also suggested, but as the latter may parasitise useful insects, it would probably be unwise to introduce it.

A new Chalcid, *Prospalangia platensis*, parasitic on the larvae and pupae of *Musca domestica* and *Stomoxys calcitrans*, has been recently described by Brèthes, and Froggatt has found a new parasite of the flesh-fly, *Sarcophaga aurifrons*, in *Dirhinus sarcophagæ*. If it is possible to utilise these insect parasites, they should aid in mitigating the fly nuisance.

It is suggested that in South Africa, possibly, use could be made of certain natural insect parasites to reduce the number of insect pests of house and farm, especially remembering the success that attended the introduction here of the Californian ladybirds by Messrs. Lounsbury and Mally to combat scale insects.

Another successful application of insects to keep down pests is the use in South Africa of a cochineal insect, *Coccus indicus*,* which is a most effective destroyer of the useless prickly pear, *Opuntia monacantha*. The insect is said not to be injurious to varieties of prickly pear useful for fodder for stock.

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* *Agricultural Journal of South Africa*, June, 1915.

Ticks as transmitters of the pathogenic Babesiæ, Theileria and Spirochætes are well known. Recently a wood tick, *Dermacentor venustus*, has been found to be the cause of motor paralysis of the flaccid type in human beings, children being most commonly affected. The bite of the tick may even cause death, and McCormack has noted that such occurs from respiratory paralysis. It is obvious that tick destruction is necessary for the elimination of spirochætosis in man and birds, of human tick paralysis and of the numerous piroplasmoses, anaplasmoses and East Coast fever in domestic animals.

Tsutsugamusi, or Japanese river fever, has been shown to be due to infection with the red mite, *Trombidium akamushi*, the life-history of which has been worked out. Miyajima and Okumura* (1916) are among the more prominent workers engaged on the problem, though many others, Kawamura, Nagayo, Miyakawa, Tanaka, Mitamura and Imamura in Japan and Hatori in Formosa have contributed largely to the subject.

The bites of the larvae of the red mite, *Trombidium akamushi*, were known to cause river fever. Miyajima considered that the bite *per se* was not the cause of the fever, but that some virus was conveyed by the mite. The larvæ nourish themselves on the wild rat, which was believed to be the source of the virus. Efforts to rear the nymphs from larvae apart from the rat were for a long time unsuccessful. Then, in 1916, Nagayo and his colleagues announced the discovery of the nymph, and shortly after Kawamura and Yamaguchi reported that they had bred the adult from the nymph after one moult. Miyajima and Okumura announced the same result a week later.

Hexapod larvae removed from the ears of rats and placed in wet sand penetrated into the sand, and in 8 to 15 days became octopod nymphs. In 4 to 6 weeks later, the nymphs metamorphosed into adults. Meanwhile other observers, of whom Tanaka should be mentioned, had found that two forms of red mite occurred on wild rats, one having small hairs, the other having large hairs. He considered that the small haired form was the true carrier of river fever and that the large haired form should be excluded. Nagayo, however, said that such differences were not specific, but were included within the limits of natural variation within the species. Miyashima then produced the disease in monkeys, using red mites that he reared from eggs, and the said mites corresponded to the large haired or wild mite. Miyajima and Okumura endeavoured to prove next whether there were one or more species of mite connected with river fever. Examination of large numbers of specimens failed to show intermediate forms, hence there were either two species or dimorphism occurred. The adults of the red mite showed no differentiation, and sexual dimorphism could not be invoked, the larvae having no sexual organs. It was found, however, that no large haired forms could be obtained except in the spring and early summer. Collections of mites from other sources gave similar results, and it was thus shown that local differences could not account for the two kinds of mite. The final conclusion reached was that seasonal dimorphism occurred, the small haired

* See review in *China Medical Journal*, 1917.

form of mite being produced in the hot climate of Formosa and in parts of Japan and Korea where the temperature is high in certain months, while the large haired forms were produced in cooler periods.

Some Sociological Aspects.

From a survey of the parasites of plants and animals just made, reflections are bound to arise as to their bearing on men, not as individuals but as a social organisation. The eminent authority on hygiene, Colonel R. H. Firth, R.A.M.C,, while in the trenches in France during the Great War, wrote a series of reflections on various problems, and in one, published in 1915,* he stated: " The fundamental idea of progress, as conditioned by the struggle for existence, involves the principle that to live, or at any rate to live ascendingly, is to strive. That universal law of striving can be broken only at the certain cost of degeneracy. . . . Feed intellectually a people on short paragraphs or cinemas, and they will be incapable of mentally assimilating anything that requires a little effort for its reception. . . . The tapeworm is a parasite and the product of long years of evolutionary striving, but, as it has made the great refusal and decided to live upon the activities of another creature, it proceeds to discard nearly all its own vital apparatus. . . . One cannot disguise from oneself that these biological principles and facts are true and have sociological applications outside the domain of medicine. We think of the low types of humanity which are parasitic on the high types, and we recall types which, in becoming parasitic, become low types A turn of thought conjures up a view of the parasitic trades, which, though sources of prosperity, really destroy more life than they produce." Indeed, Colonel Firth states later that " the whole trend of social evolution points to there being less room in the future for parasites in the body politic." An unfortunate application of this theme is to be found in trade conditions at the present day, where the producer and the consumer do not reap adequate benefit, but undue profits seem to go to the middleman. In communities where the wealth accumulates in the hands of non-producers, there can be no real stability, material or moral.

Another important matter is over-attention to and over-indulgence in athletics in our schools and universities, and this is threatening even to sap our vitality and progress. At the present time, sport is over-emphasised and is praised in the Press in such inflated and exaggerated terms as can only be described as ridiculous on calm reflection. Such statements are also spoiling and degrading our language. These remarks may be considered to be severe, but I would respectfully refer to the important American weekly, *Science*, of May 19th, 1922, wherein is a paper entitled " Science or Athletics? " by Professor E. G. Mahin, read before the section on Chemical Education at a meeting of the American Association for the Advancement of Science, held in April. In America athletics appear to take a more prominent part in college life than here, but the warning is needed. Professor Mahin writes: " We respectfully submit that in the effort of the college to administer courses of training, either routine or research

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* *Journal of Royal Army Medical Corps*, xxv, pp. 664—666.

in purpose, there are certain factors that constantly baffle and discourage." He continues: "The undue *multiplication* of student activities and campus side-shows plays an ever-increasing part in the pulling down of the educational system with which we have laboured so carefully and so painfully, and in the dissipation of the scientific efforts of those who should be our best students. Superficial training is the inevitable result, and superficial training and narrowness of viewpoint are the blight of our system of scientific education to-day." Again: "Our colleges are spending relatively enormous sums upon athletic activities whose end is not, in any sense, physical development of the students, but solely the winning of games and championships, while the educational needs are grievously suffering through lack of support. . . . We are losing the sense of perspective in educational affairs." The Professor, while risking the appellation of "alarmist," writes of those who consistently practise "living the life" of the college by becoming "all-round" men and participating in every possible activity, that they, with few exceptions, "make up the army of fillers of small positions, doers of small things and thinkers of small thoughts." I fear that what is true of America is liable to become true of other parts of the world, and that excessive sport is tending to become parasitic on legitimate occupations and studies, exerting an adverse influence on mental capacity and on moral obligations and sense of responsibility. Sport in moderation is healthful and desirable.

About the same time an interesting article on "Individualism in Medical Education," by Prof. A. C. Eycleshymer, appeared in *Science*, April 28th, 1922, being the substance of an address to the Association of American Medical Colleges in March. He emphasises that there are two factors in medical education, individual thought and collective thought. The development of community life emphasises collective thought, but with the increasing restrictions brought about by unity of purpose and organisation, "individuality is forced towards the average." Again: "Great leaders—philosophers, statesmen and scientists—are those who have resisted these equalising forces. . . . If the development of individuality be ignored, one of the greatest forces in the progress of mankind is lost to the world." The traditional home of individuality is in the University, and here is the one place where it should be fostered and encouraged. On the other hand, the principle of collectivism is a necessary part of modern social organisation. Many combine together for a common purpose, but each realises that what is present in himself is moribund, that he is physically an automaton and intellectually at the lowest level. The remedy must be sought in greater liberty in medical education, according to Dr. Eycleshymer, and while "every medical problem must be approached through the avenues of physics, chemistry or biology," the physician needs to be able to determine which will help him most in any problem, and probably finds that all are involved, for it is necessary to emphasise the need "of working through the avenues of multiple hypotheses in the interpretation of disease." Such needs remembering in South Africa, where, owing to the insistent clamour of the amateur and the uneducated, there is a tendency to try to force too early

specialisation and to eliminate the essential bases of medical practice—chemistry, physics, botany and zoology—and to hurry on to the study of what are grandiloquently termed the " professional subjects." The fate of superstructures built on insecure foundations is well known.

There is need here, as in America, for provision for research and investigation. It is not enough to provide merely staffs equipped with knowledge. " Teaching must be accompanied by thinking; teaching and research are inseparable," says Dr. Eycleshymer. I emphasise the necessity for the research worker as the vitalising power in education generally. No mere " useful hack " can advance education, nor can the classical egoist, who states that there is no need for experts, and that his own " commonsense " can solve any problem, really do other than degrade education and sink educational ideals. Leaders of thought and inspirers of men are needed, not apostles of parochialism; breadth of vision, not the narrowing of outlook to the pages of text-books or the study of dead languages; a live knowledge of the present, not a sort of parasitism on the past. As Prof. Eycleshymer says: " He who comes from the land of mighty oceans, forests and mountains, thinks in larger terms than he who comes from the truck farm." The moral is obvious—it is a fatal mistake to have at the head of affairs young, inexperienced men, who have never had the time to acquire breadth of view or a knowledge of the world, and who are trammelled and shackled at every turn by their early training, in which science had no part, and where the cramping influence of " village " life has left a permanent mark. No matter how " brilliant " or " precocious " such a one may be, he is unfitted for great positions that demand thinkers of big, broad thoughts, doers of great actions and utilisers of the practical experience acquired by wrestling with Nature itself, and not merely wrestling, but prevailing. Only older men, who have acquired experience through service, are really fitted to be placed in control of their fellows.

An unfortunate feature of recent years in the field of biological research, at any rate in that of animal parasitology, has been the relatively young worker with the so-called " critical faculty " unduly developed. Sometimes by hurrying over or neglecting to peruse the work of earlier investigators, or by undue use of the method of partial quotation, such a writer expresses himself in terms of strong condemnation of the work of others and becomes autocratic. What is needed in science is the worker of clear, unbiased views, who sees that seemingly conflicting statements are not really in conflict, but represent, as it were, different views of the same landscape. The landscape is unchanged, but the appearance of it differs with the angle at which it is viewed. The scientific worker who has the happy faculty of reconciling apparently contradictory statements by fellow-workers, and showing that they form parts of a harmonious whole, is of far greater value to the community at large than the one who destroys such work and sets up his own views as solely correct. Such self-constituted autocrats are often fond of the expressions " claims " and " alleges " and similar hyper-critical

remarks, with emphasis on negative results. Doubtless time will place these writings in their true position, for one positive result is of more value than many negative. Healthy scepticism is necessary, but it must be remembered that while legitimate criticism is always welcome, yet when it degenerates into mere retort and negation, it is subversive of progress.

The daily Press also is responsible to some extent for the attitude taken up by the public in regard to science. A harmful article was published quite recently in Johannesburg by A. K. Chesterton, termed "The Tyranny of Science," which article, for concentrated sneers at science—knowledge or truth—and advocacy of sentimental, self-satisfied ignorance, would be hard to beat. Science to him is a "dangerous thing"; the "intolerable despotism of science" is a thing to be broken down; we have "to smash down the cruel superstitions of science and build up again the everlasting truths of poetry." Similar foolish remarks such as "science killing the soul" pervade the whole article. Such publications discourage the true scientist with first-hand information from writing for the Press, as has been well expressed recently in the United States by Dr. W. E. Allen. Also, in this connection, I regret that time and space do not allow of my repeating and amplifying the remarks made by the President of this Section last year, which are to be found on pages 95-98 of Volume XVIII of the *Journal*, when some attempts were made to show that science, religion and poetry are not in permanent conflict.

Kindness, pity, sympathy and charity are among the highest human attributes, but, unfortunately, they may be abused and directed into wrong channels, until the giver may unwittingly make the recipient like a parasite, with inevitable and disastrous consequences. Biological principles underlie even sociology.

The scientist, often unappreciated by the public, must live a life of incessant striving, yet the investigator's life has its ideal aspect in that it adds to the sum of human knowledge. In 1908, Rudyard Kipling, a great observer of nature, addressed a meeting of medical men in London and gave them this message, which, being applicable to science even more than to medicine, I pass on to you in conclusion. Kipling said: "You have been, and always will be, exposed to the contempt of the gifted amateur—the gentleman who knows by intuition everything that it has taken you years to learn. You have been exposed—you will always be exposed—to the attacks of those persons who consider their own undisciplined emotions more important than the world's most bitter agonies—the people who would limit and cripple and hamper research because they fear research may be accompanied by a little pain and suffering. But you remain perhaps the only class that dares to tell the world that we can get no more out of a machine than we put into it, and your training shows you daily and directly that things are what they are, and that their consequences will be what they will be, and that we deceive no one but ourselves when we pretend otherwise. Realising this, I would wish you, in your future, what all men desire—enough work to do, and strength enough to do your work."

CERTAIN ASPECTS OF THE NATIVE QUESTION.

BY

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Native Affairs Commission.

Presidential Address to Section E, delivered July 13, 1922.

It is a commonplace to say that the most difficult and also the most serious problem in South Africa to-day is the Native Question, in all its manifold bearing. It is difficult and serious because it is inextricably bound up with so many national activities and conditions. In mathematical language the Native element in any problem is the variable coefficient which gives to that problem its place and potency.

It needs no demonstration that the Native problem is bound up with the social life of the land: that it has the most intimate and direct bearing on the economic progress of the people of the land: and that it is evermore and always on the horizon of matters political. We cannot get away from it in this southern land. It meets us everywhere; in the kitchen, on the farm, at the docks, down the mines, along the railways. And ever and always it is an immediate incentive to hot discussion and biased judgment.

Yet we aver that there is no question under the sun that demands a clearer outlook, a calmer mood of mind, and a more unbiased attitude of soul and sense, than this unsleeping, unresting, and unhasting problem of black and white in the splendid land that is the common home of both races.

Now it may seem unfair to bring so moving a matter into the serene atmosphere of a Science Congress. But that is just why I do bring the problem here, so that in the calmness and fairness which science claims as its true environment, from the days of Plato and Socrates down to these remarkable times, we may look at a question so complex and so laden with fate for our land and people, in a spirit of honesty and of courage.

In a matter so complex as the Native problem is, and so interwoven into the fabric and circumstances of our national life, it is not possible to deal with it in an exhaustive manner. To do so, even if one were to make the attempt in a superficial and imperfect way, would require not an hour, or a whole day, but a whole lifetime, for, as has already been urged, every issue and question in this great land is connected, in one form or another, with this outstanding problem.

So, with the forbearance of my readers, I shall consider only four or five of the more immediate and more pressing aspects

of the problem, a problem which is raising so much anxiety in the minds of thoughtful men; and this southern land, I think, has more of these per thousand of the population than any other corner of God's earth. And the reason for that intellectual aliveness is just this very array of problems of race, labour and climate, which our people have continually to face. So, after all, perhaps, the race problems, and the labour questions, and the handicaps of drought and disease are really blessings.

But to return more pertinently to the matter on hand. Among the four or five aspects of the Native problem which may be considered immediate and pressing, the following may be regarded as worthy of our closest consideration:

(1) The changes in national life and mental attitude due to the passing of the old tribal system of government, based as it distinctively was on a communal idea of national relationship.

(2) The immigration of the Native into industrial areas and the changes in habit and in outlook due to this immigration.

(3) The character and direction of Native Education.

(4) The possibility of the extension of opportunities of work for educated Natives.

(5) Their political future.

1. *The changes in national life and mental attitude due to the passing of the old tribal system of government, based as it distinctively was on a communal idea of national relationship.*

Although racial changes take place very slowly, and racial mental characteristics are to some extent as permanent as the physical features of a race—some writers think more so—at times a sudden economic change, or the alteration of one's sky (Horace notwithstanding) will bring to pass, in a brief century, a more altered state of things for a race than the previous thousand years of their history have witnessed. Take, for instance, the change brought about in England and Scotland by the great industrial development of a century and a half ago. In a few years a large proportion of the people passed over from one economic age to another, from individualism to collectivism, from simple primitive occupations to being parts of a vast industrial machine. It was a new England that arose out of the new conditions. Then, again, a nation like Japan moves down untold years tranquilly and untouched by change; suddenly there bursts upon it, like a geological cataclysm, a great tidal wave of progress, submerging under its waters much of the old condition of things. In ten years the past of ten centuries is almost washed away.

Change cannot be measured by years. It is not the inert static condition of mind and manners of a race that means so much in the way of change or the reverse, but rather the quality and quantity of the dynamical forces acting on that mind and those manners. True, some Natives are more conservative than others, but no amount of conservatism will stand the steady wearing down pressure of outside influences.

So when one advances the argument that the coloured people of this land must take as many years as we have done to travel the painful upward way of progress, that person is shutting his eyes to the teachings of history, and is unobservant of the vast changes that a sudden alteration in the mode of life of a people will bring about in a few years. As we have said it is the dynamical forces rather than the statical that control and direct the changes in the habits, race movements, and ultimate goal of a people. Where the statical forces are strong, as in the case of the Chinese, then the changes are slow.

What have we in the case of the Bantu people? Here we have an adaptable, imitative, warm-hearted, alert-minded race, whose conservatism is social rather than political, faced, and even surrounded, by an advanced modern civilization. Shall this race take two thousand years to accustom itself to, to understand and to share in, this modern civiliation? Because it took centuries to move forward from Volta to the modern motor car, will the denizen of Woodstock take centuries to learn how to drive a motor car?

True, we must make allowances for the peculiarities and pertinacities of race. Underneath the civilization which the Bantu may acquire there will always be something belonging to his peculiar people. The human soul is very impressionable, and if the English Public School will leave upon its children the indelible imprint of its influence, how much more the by-gone generations of Native habits and ways. But that, in the future, may only give a charm and a character to a new aspect of civilization just as the Celtic minor undertones give a pathos and a romance to every act and every song of that ancient and winsome people.

What are the circumstances that conspire for rapid change in the case of the Native people? Take the ordinary dweller in a native village. To-day almost every native home uses tea or coffee, bread or cake, jam or preserves. Then every individual of that home, except the little children, must clothe themselves in some sort of garments, preferably clothing approximating to those worn by Europeans. These clothes are worn because it is right and decent to do so. There are other changes in the old mode of life, but let us consider these simple ones, changes common to every Native village in South Africa. Think what a chain of economic circumstances, circumstances wholly alien to primitive Native life, even these give rise to.

To buy tea or coffee, bread or cake, jam or preserves, sugar or salt, money is required. To obtain money, work or worth must be given in some form. This means that some one has to go and work somewhere. And at once the machine, the modern economic machine, begins to work inexorably. We can hear the whir of its great wheels! To get work one must travel—a new experience from which the childlike soul of the untutored Native returns no more as it went forth.

Now travel means Johannesburg, Durban, Cape Town, Port Elizabeth. And Johannesburg, Durban, Cape Town and Port

Elizabeth become verily a new experience to the Native. Then he must obtain clothing for himself, his wife or wives, and his children. The latter dare not go to school unless they are properly clothed. And thus he learns, without the aid of Carlyle, that clothing has much to do with modern civilisation. To him, alas too often, Christianity itself becomes inseparably connected with trousers.

Again, clothing means money. And so the eternal round runs on. Every new want can only be supplied by toil and labour. And toil and labour, *for others*, means a new outlook for the labourer upon life.

All that we have just stated is in the way of being a parable illustrating the effect of new conditions upon the habits of thought and life of the Native people. We have chosen the simpler elements of change to exemplify what we wish to convey. We can readily enlarge our parable. Changed food, altered conditions of life, new thoughts, wider aspirations (especially for the children), individual possession rather than tribal and communal tenure, travel, and all that travel brings, newspapers, congresses, councils, new customs, and modern habits, all conspire to make of the old-fashioned native a new man. It is new lamps instead of the old in very deed.

And thus there is swiftly growing up in our midst a new Kafir race. I make bold to say that even in physical features a great change is coming over the Native who is conforming more and yet more to modern ways of civilization. Education is reforming the features of the children to a wonderful degree. And in this direction it is interesting to state that the shape of head of many of the outstanding Native leaders is quite different from that of the ordinary kraal Native. There will naturally arise the objection in the mind of not a few that the head of a Merriman or a Smuts is even further removed from that of an average tramway conductor. This is true, but we insist that in the case of most Natives education is producing, as we would naturally expect it to do, a distinctive type of face and head.

The writer speaks here from personal knowledge, having in his own time taught three generations of pupils. And he can aver with very definite certainty that in the case of many Native families the softening, spiritualizing touch that the finer forces of civilization bring to bear upon a race is very apparent. It could not be otherwise, surely, in a people so emotional and so impressionable as the Native people are.

There are other changes going on of even greater moment to the Native as a people. The steady unstoppable breaking down of the tribal system all over the land, the passing of many of their old customs and ways, the growing desire for individual possession, all mark political and social change of grave moment and importance. There is, no doubt, among the older men, and notably among the chiefs themselves and their immediate following, a well defined desire to go back to their ancient modes of government and their age-long habits of life, but this is only a natural struggle, and a hopeless one, on the part of the old against the imminence and aggressiveness of the new.

The younger men, and especially those who have experience of the unity and solidarity of the European races, urge a united racial movement on the part of all Bantu people. This movement, which is very widely spread, is of no ordinary significance for it is based on race consciousness, one of the most potent forces in the development of any people.

A generation ago I thought the trend of history, in these later years, would be for the Native to break up into a congeries of isolated and unrelated parts, each section simply living its own meagre life of dependence and of hopelessness. I have no longer that view. There is, right over the land, a growing feeling among the Natives of race consciousness; an increasing pride in the dignity of race, and a very definite hope with regard to the future. This movement towards unity, unity of thought, and of purpose, and of action, is making considerable progress in the Cape Colony, but less so in the outlying portions of the Union. At present we stand between the old and new.

Fortunately, the graver-minded men of both races are deeply concerned with the dangers that such a time of transition gives rise to, and in many of the prominent centres of the Union associations have been formed, composed of leading men of both races, with the purpose of guiding and informing public opinion, and specially of bringing the most outstanding men together for a common cause, the welfare of South Africa.

Although at various times in my career my thoughts as to what the future of the Native people would be have changed considerably, I have never wavered in my conviction that whatever road we travel along we must travel it together as comrades, or the way will be strewn with ruined hopes and the end will be possible disaster. It is impossible in this complex and strange land for one race to do without the other, and the safety and salvation of both depend very largely upon mutual and sympathetic understanding.

It was in this spirit that I embarked upon the present address, that I venture to deal with questions bristling with difficulties and perplexities, that I urge a course of action and thought upon mine own people that may not generally commend itself.

The Native has entered upon a period of transition, a difficult time in the history of any people. It is the impact and the demands of the white race that has brought this condition about. We urge on the part of all men a wise and sympathetic understanding, much patience and forbearance, a generous outlook on waywardness and weakness, for at such a time of unrest and disquiet, folly and imprudence in word and deed will not be wanting.

As old traditions lose their power, as old customs cease to charm, as old restraints grow weak, as old habits pass away, and as new methods of conduct come into being, the Native will be a good deal the sport of many winds. It is for those who respect his fine qualities and honour his many manly virtues to see to it that he is kept from drifting on to lea and treacherous shores.

II. *The immigration of the Native into industrial areas and the change in habit and in outlook due to this immigration.*

The needs and demands of European trade and commerce, of mines, harbours, railways, industries as well as of homes, have drawn the Native towards the great urban centres. On the Reef alone there are a quarter of a million Native employees. At the seaports they are there in their thousands. All along our vast net-work of railways they toil. Even the meanest home boasts a kafir boy. He is part and parcel of the great South African industrial machine.

In past days the Native who came townwards always kept his cables moored to his native home. He only went forth to seek work when necessity or vanity or wonder constrained him to go; and it was ever and always " Home " that held him and his, not the compound on the mine, or the lodging at the docks, or the tent by the railway, or the back-yard attached to his master's kitchen. It was always " Izekaya "; for that he toiled, for that he saved his money, and no day was more joyous to him than that on which he set his face homewards.

But in these later days much of this is changed. The Native, now, settles down more readily to town or location life, and the insistent call of home is no longer there, or, if it is, there is but a whisper of hills, and woods and streams which a night at a cinema show blots out.

Too often the ill-smelling, badly-built, fever-haunted collection of sods and tins and rags, so frequently met with, and which we call a location (a place, not a home), is his permanent dwelling place.

We have already spoken of the changes going on in rural areas in Native territories. What changes in life and living will not locations bring about; what kind of a people will many of the locations we know rear as workmen of the future? Do we wonder if the Native is physically and morally beggared by living in them? What is there in these locations to uplift or ennoble? How many of them have a recreation hall, or a small library, or even the natural conveniences of water and light? Then it is the worst side of European life that the Native usually witnesses. The best is a closed door to him. And if he were a cloddish soul it would not matter much. He would be uninfluenced by what he sees. But he is far otherwise. There are few races so imitative, so observant, so quick to see beneath the surface of things. A leading Natal newspaper dealing with this very condition of things said of the Zulu who came down to the seaport from some far-off village that in three weeks there was not much of the underworld of Durban life that he did not know. The same may be said of the Xosa boy who drifts into the back-yards of Johannesburg, or the slums of Cape Town.

It is matter for thankfulness that the Government of the Union, not ignorant of the unsatisfactory condition of so many of our locations, has introduced a measure dealing with a number

of the evils that we have so briefly dealt with. It is to be hoped that the new conditions arising out of the new measure, which we trust will prevail all over the Union, will secure village homes for our Native urban residents; that these villages will be made so attractive that no longer even the best Natives will desire to live in European towns. Natives will be given a say in the management and direction of their own dwellings: what is obtained from them in the way of taxation and fines must be returned to them for the betterment and upkeep of their village. In this way a municipal conscience may be created among the native people, and a desire begotten to take their share in the administration of what are peculiarly native matters and concerns.

III. *The character and direction of Native Education.*

The question of the character and direction of the education which is best suited for Natives is one of no ordinary importance, for the character and direction of the education and instruction which is imparted will to a certain degree influence the future of the race. We venture, however, to think that the potency of the factor in determining their future has to some extent been overestimated. Indeed, the influence of education, that is education in its more limited sense, on the fundamental character of any people is probably very small. The great virtues of courage, justice, courtesy, manliness, are untouched by book learning. Moral teaching will without doubt, enhance these fine qualities by giving a reason for their existence and a direction for their expression; but ordinary instruction cannot be expected to do either of these.

It seems very reasonable to hold that the principal purpose of education is utilitarian; it seeks to make a man a useful citizen; its aim is to bring out what is best in him so that he may use that best in the service of humanity; it brings knowledge within his reach so that the mental wealth he thus acquires may be the means of his adding to the happiness and comfort of others. And because education has thus a direct bearing on the welfare of a country, all civilized nations make it a state matter. The state gives in order that it may get.

Now we do not purpose here to meet the oft-repeated and always foolish statement that it is better not to educate the Native, or to refuse the untruth that education spoils him. Statements of that nature require no refutation, for they have little sympathy or sense behind them. Sound education can never in any circumstance, or in any age, be harmful to any people.

But the quality and kind of education that we impart is another matter altogether. And since we accept the premise that education must in the main be utilitarian, the question of the character and direction of the education that we give to Natives, must be settled by the test of its usefulness. Is the present system of Native education suited to the needs of the people? In seeking to answer this question we must bear in mind the historical development of the people.

Sixty years ago the great bulk of Natives were uneducated. But there was the birth of an unpassing demand for education,

for schools, for institutions of learning. It was a worthy desire on the part of the Native people; and the governments of that day, especially that of the Cape, answered the call by sanctioning and aiding schools all over the Native territories, and by starting training colleges for the instruction of teachers. For fifty years and more the chief object of Native education has been to train teachers. The land needed elementary schools and in response to that need our Native Institutions spent practically all their energies, and nearly all their funds in supplying teachers for these schools. The conditions of this time of transition demanded that this need should be met.

But with education so general now, and the supply of teachers greater than the demand for them; with the deplorable congestion that is taking place in many Native areas; with the new political vision which we hope the institution of the Council system will give to our Native people; with their entry into so many of the industrial activities of the land, the old system of a restricted curriculum suited to one direction only is out of date. It has served its purpose, and served it well, and no man honours the old simple system more than the man who has given half the allotted span of his life to its service.

The new ideals in Native education ought to lie more in the direction of material progress. Wealth is not necessary to progress but poverty is a distinct hindrance, ever and always, to a people's advancement.

Better means of agriculture should be taught to the Native people. To some extent this is done in the Transkei, but it should be general all over the country.

Then home and village industries should be encouraged. Until the Native has breadth of opportunity, variety of occupation (and that at his own home) he will never be anything but a machine.

One counts up in a rough way the number of boys and girls, between thirteen and eighteen, in Native areas who are doing nothing. They have left the village school. They are too young to go to the mines or to the towns. Their parents are too poor to send them to institutions to be taught. And so it is idle hands and idle thoughts; service which might be given to the state running to waste. There must surely be some way of occupying these idle hands, those idle thoughts. And the best way we can think of is the creation and fostering of simple village industries here and there and finally everywhere.

The fundamental elements of education must be the same for all races, and in all times. The young must be taught to read and to write and to count. Habits of application, of industry, of good manners, of manliness must be impressed upon our children. The basic principles of good citizenship ought not to be forgotten. No new system can change this. It is when we get to the upper structure of our educational system that the enquiry comes; is this just suited to this people: to their circumstances: to their line of progress: and frequently I think the answer is that it is not.

IV. *The possibility of the extension of opportunities of work for educated Natives.*

We here enter into a region of great difficulty, into matters that require extreme delicacy of treatment. It may be thought by some of my associates in this important Congress that it is a region and a matter that should be left severely alone. This may be so. Still I think it is due to the Native people that we men of science, who are supposed to look at grave and great questions in a dispassionate manner, should know what thoughts circle in Native minds concerning the limitations that habit and custom and social and economic conditions have placed upon them.

The wiser and more moderate men realize the reasonableness, from some points of view, of these limitations although they regret their existence. It is very, very rarely that any seek to break them down, for the Native is, above all else, an upholder of custom and tradition, even if it be the custom and tradition of another race. He is marvellously law-abiding. For him what is, is!

But in conversation one gets behind the outposts of his mind. And then we gather the regret there is among the more intelligent men that certain doors are closed to them. They cannot rise in the Civil Service above the rank of messengers or interpreters. The most-educated Native need never aspire to become a magistrate even among his own people. In the larger native schools there is no recognized view which gives him preference over a European. And as regards salary, the disparity is, to him, anything but reasonable.

Will time break down these barriers: or are they fundamental; will the years only witness an accentuation of the position that at present exists wherever occupation, or work, or station or salary is concerned?

V. *The political future of the Native.*

If the previous matter was one of extreme difficulty, this is no less so. On this question many men in this land have very strong convictions. I have met men of great prudence, of calm judgment, of much sanity in political matters who say, "Give the Native equal rights with the white citizen of South Africa."

This was the Cape view, and still obtains among the older men of that Province. I have also met men of wide sympathies, warm-hearted men, men of moral worth, of lofty ideals, who have said to me: "The Native should have no political privileges of any kind. This is a white man's land."

Between these two opposite and opposing schools of political thought in Native matters the truth must somewhere lie.

In the direction of giving to Natives more say in the affairs that affect themselves more immediately, the recent Native Affairs Act of 1920 has been brought into existence by the present Prime Minister. This Act makes possible the creation of councils in purely Native areas where such bodies are demanded by the Natives of that area. These councils will deal with many of the matters now under Divisional Councils or other local bodies. The success which has followed the working of this system in the

Transkei raises the expectation that, in other parts of the country councils carried on along nearly the same lines will be acceptable to the Natives, as it gives to them the management of such local matters as concerns themselves directly.

The Urban Areas Bill also proposes to give Natives in or near towns a considerable say in the control of their own affairs. This new departure in local government will, we think, be of great service to the Native people generally.

These are some of the grave questions that are within the rim of our immediate consideration. This is, and has always been a land of problems. This is not as some hold a misfortune. It may indeed be a blessing. To the existence of these manifold difficulties may be due the fact that we have never lacked in this land great statesmen, or wise philanthropists, or able teachers. Our very difficulties create the means of dealing with them; give us the men to cope with them.

I have written at greater length than I meant to when I began; but the importance of my subject is my excuse.

We will never make progress in the solution of any of the aspects of the problem unless we try to understand the Native people. The problem would have less of danger in it if we understood each other more. And the measure of our success in solving the problem will be the measure of our understanding one another. That the one race will fully and perfectly understand the other is impossible. Traditions, and customs, and beliefs, and language all create barriers in the way. But we ought not to be comparative strangers the one to the ways and thoughts and aspirations of the other, as I think too often we are.

I crave forgiveness for this personal note but I am convinced that with a race so peculiarly constituted in temper and in attachments as the Natives are, it is the personal aspect of things that count.

REMARKS ON CERTAIN MENTAL DISORDERS WHICH MAY BE REGARDED AS PREVENTABLE.

BY

J. MARIUS MOLL, M.D.

Presidential Address to Section F, delivered July 13, 1922.

Few diseases cause more distress and unhappiness to the patient and to his friends than mental diseases. No other disorders affect to such a great extent the social and economic efficiency of the sufferer. And no other class of patient, after he has got better, is branded with the stigma which attaches itself—though very unjustly—to many a recovered inmate of a mental hospital. Also, if a person recovers from a mental illness, this recovery, unfortunately, is often not total nor lasting. Therefore, in no other kind of ailment would prevention be more desirable and of greater importance to the individual as well as to the community.

In this address I propose to give a short survey of certain important kinds of mental disorder which are, or which we are learning to regard as, preventable; and to discuss shortly the lines along which this prevention lies.

The possibilities of preventing disease naturally increase with our knowledge of the etiology. It is not always necessary to know all the details of causation, as long as we know certain factors, *e.g.*, we are still ignorant of the micro-organism which causes smallpox. Notwithstanding this, the methods of preventing the occurrence of this condition have developed to such a degree, that it has became a rare exception amongst civilised people. Now, what do we know of the etiology of the various psychoses? With regard to some we know a good deal; especially during the last twenty-five years our knowledge has increased and deepened. But with respect to others there are still many important points about which we are totally ignorant.

Jelgersma divides the mental disorders into two main groups, the "intoxication-" and the "germ"-psychoses. Those of the first group are caused by an intoxicating agent, a poison in the widest sense; it is either introduced from without, or can also be produced inside the body itself. These psychoses, if their course is not checked, lead to structural changes of the brain (demonstrable under the microscope) and end in a terminal dementia or disintegration of the personality. In the second group which has also been called "functional psychoses" there is no etiological poison, no microscopic alteration of brain-cells and no dementia. Although this system is open to criticism on some points, its basic principles have much to commend themselves.

I shall first deal with a few psychoses, which clearly belong to the intoxication group.

It is not necessary to say much of these forms of mental derangement which occur during the course of physical illnesses and which are only caused by the toxins of these illnesses. Take, as example, the delirium which is occasionally seen in patients suffering from enteric fever or from sepsis. Without the primary sickness no mental symptoms would have occurred.

As soon as the original affection improves, the mental picture clears up, in the vast majority of cases. Therefore, the prophylaxis of these psychoses is simply that of the underlying physical condition. Now and again it happens that an infectious disease, if it is of prolonged duration, has an exhausting effect, and that, especially if the patient goes back to hard work before he is fully recovered, a mental affliction becomes manifest. The prophylaxis thereof is obvious, although in many instances it is much easier to give the advice than to follow it.

Amongst the intoxication psychoses, those caused by alcohol occupy the foremost place. In almost any form of insanity we find cases where alcoholism has to be regarded as one of the precipitating factors. But besides these there is a whole group of mental disorders (in which alienists distinguish some eight or nine different kinds), where alcoholism is undoubtedy the principal factor if not the only factor; which, in other words, would never have occurred if the patient had never touched liquor. The degree of alcoholisation required to cause definite mental changes varies greatly in different individuals: one man may become the inmate of a mental hospital through the consumption of less alcohol than many others can take with apparent impunity. The most frequent alcoholic psychoses are: delirium tremens and hallucinosis. The prognosis of each individual attack is fairly good, but unless the patient has learnt his lesson thoroughly and leaves alcohol severely alone afterwards, there is great danger of recurrences. I have frequently seen patients who had recovered and who had sworn great oaths never to touch a drop of the poison again, admitted two, three and four times within a few years, with a mental picture, photographically the same on each occasion. During every attack, however, the patient runs a certain risk of dying from exhaustion or from a complication, like pneumonia. Of the chronic forms I may mention Korsakow's disease and the various degrees of alcoholic dementia, from which there is no recovery and which make the sufferer generally fully a social outcast and dependent on care by others. This is not the place to discuss the general merits of total prohibition. A strong argument in favour of it is this occurrence of alcoholic psychoses which would never have developed if the individual had left liquor alone. According to statistics of certain big cities, the incidence has been from 20 to 40 per cent. of all psychoses admitted to institutions. In South Africa this percentage of the admissions for the years 1919 and 1920 was 11 per cent. The actual number is much larger, of

course; think alone of the number of cases of delirium tremens which never reach a mental hospital, because they have died beforehand for want of proper treatment; or of the many cases, with less violent symptoms, who manage to struggle through their attacks somehow, but who during this time cause much anxiety and excitement to their surroundings.

Amongst the troops that could not get excessive quantities of drink during the great war, the incidence decreased considerably; and the same appears to have happened in America since prohibition.

There are a few other poisons and drugs the excessive use of which at times causes mental derangement; for example, veronal, morphia and cocaine. The incidence of these psychoses is, however, not great, although there are indications that it rises in places where alcohol is prohibited. In the native mental hospitals of this country we see a certain number of psychoses where *Cannabis indica*, or dagga, is the only or the most important etiological factor. Here again, we shall be able to prevent the mental diseases so caused, if we succeed in the prevention of the use of these drugs.

I have already mentioned that in the course of certain acute infections mental disorders may occur. Amongst infections of a more chronic character, none is more important and disastrous in its relation to psychiatry (and neurology) than syphilis. The study of this affliction received a fresh impetus in 1905 through the discovery by Schaudinn and Hoffmann of the micro-organism which is responsible for it, *Spirochœta pallida*. A few years later, Ehrlich and Hata succeeded in manufacturing salvarsan (and subsequent derivatives) and new avenues were opened up for more extensive and effective treatment. In the latter part of last century alienists had already realised the probability that a previous syphilis infection was often responsible for the development of certain nervous or mental diseases. Thanks to more accurate clinical and laboratory methods, this probability has become a scientific fact, and we now know for certain that a great number of patients of psychopathic clinics are there solely on account of a previous infection. The figures for the Union for 1919 and 1920 are surprisingly low, for example, 6 per cent.; a few years ago they were distinctly higher. Further, syphilis, like alcohol, may be a contributing factor to almost any form of insanity. The percentage of admissions where lues is *the* principal factor, varies greatly in different places and years, namely, 4 to 36 per cent. The most frequent and important psychosis of this kind is the so-called progressive or general paresis, an affliction which usually attacks people in the prime of life, and which, with a great variety of signs and symptoms, almost invariably leads to a progressive mental and physical disintegration, and finally death. For it must, alas! be admitted that while our methods of treating the first, second and third stages of lues have improved considerably of late, we are still well-nigh powerless with regard to general paresis. It is true, that by means of the modern treatment we succeed more fre-

quently than formerly in bringing about far-reaching remissions, which, as long as they last can be equivalent to a cure; unfortunately, these remissions are not of long duration and are nearly always followed by a relapse. Cases of paresis in which an actual cure has been effected have only been published as extremely rare exceptions. This psychosis only becomes manifest many years (up to twenty) after the primary infection. It is, therefore, a very difficult matter to get a reliable estimate of the number of primarily infected persons who ultimately become paretic. With regard to this most important point, Mattauschek and Pilcz have compiled very valuable and accurate statistics of over 4,000 officers of the Austrian Army, whose subsequent histories could be followed for a sufficiently long number of years. For this material they found an incidence of paresis of 4·7 per cent., or nearly one in twenty. In other places figures have been found which are either somewhat lower or considerably higher. At any rate, the fact that this dreadful and fatal condition awaits a certain number of infected persons, and that it could not possibly occur unless infection had taken place, is one of the very strong arguments in favour of effective general measures to combat venereal disease. It is gratifying to note that measures have been taken in the Union of late to establish venereal clinics in some of the bigger centres.

There is one other infection which is inclined to run a protracted course, and which is of practical importance in many parts of our country, namely, malaria. Its relation to mental disturbances is less clear than in the case of syphilis, neither has it been studied as extensively. At any rate, there is no specific group of "malarial psychoses." But in the history of some mental patients malaria in repeated attacks figures as an apparently important factor. And often one cannot help thinking that without the malaria, the patient would not have become insane. According to Dr. Leipoldt, malarial infection is also an important factor in the causation of intellectual retardation and enfeeblement. There can be no doubt that eradication of malaria, apart from all other benefits, would also improve the general mental health and vigour of the population.

The psychoses which I have mentioned so far, clearly belong to the intoxication class. Another kind of insanity which also comes under this heading, is the group which was formerly known as dementia præcox, but for which Bleulers' name of schizophrenia is undoubtedly less inaccurate. This disease is extremely important, if only because of the very great incidence. The figures vary according to locality and investigators, but we are not going far wrong in assessing them at roughly one-fifth to one-third of all the admissions to hospitals for the insane. The percentage in the Union for 1919 and 1920, as published in the Commissioner's Report, was 21. In some institutions it has been found to be as high as 50. An appallingly large number, surely, more particularly if we realise that the major portion gradually deteriorates and forms the demented residue of the mental hospitals. Of the minority which get well enough to be dis-

charged, only a part recover altogether and can fight the battle of life unsupported. Apart from the official and statistical numbers there are undoubtedly not a few cases where the disease never develops far enough or violently enough to warrant their admission to an institution, but who, nevertheless, have to go through the rest of their lives with impaired mental and economic efficiency.

It goes without saying that an entire, or even partial prevention of this condition would be a tremendous boon to humanity. But we have not attained this ideal yet, although our anatomical and clinical knowledge has made great strides during the last thirty years. There is evidence to show that a disturbance of the function of one or more glands with internal secretion plays some sort of rôle; Mott has shown that far-reaching organic and microscopic changes of the reproductive glands occur. Substances have been found circulating in the blood which suggest that a demolishing process is at work in various organs and tissues of the body (Fauser). The exciting agents, however, which cause these organic changes we do not know.

Again, in many cases it is evident that strong psychical powers are in action, that fundamental conflicts have arisen with which the individual is unable to cope and which cause the psychotic upheaval. Some schools of psychopathology (Freud, Jung) regard this disturbing action of certain conflicts and complexes as the primary cause in most cases, and are of opinion that the organic changes are only secondary and caused by the profoundly disturbed function of the mind. To further dilate on these different views would carry me too far afield. It is sad to relate that cures are few and that with regard to preventing this condition we are also still groping in the dark. We can ill afford to rest contented with this state of affairs. All over the world numerous investigators are endeavouring to find at least the beginnings of the solutions of the problems that are waiting for elucidation. In our country very little has been done so far in this particular direction. There is no reason to believe that the field here would be less fruitful than in other countries. On the contrary, it is not at all unlikely that the study of psychoses as they occur in our primitive races (W. Russell found roughly one-third of the inmates of the native mental hospital at Pretoria to be suffering from dementia præcox) would yield valuable keys to the solution of the more complicated problems as they present themselves in white people.

I now come to the "functional" mental disorders, or, as they also have been called, the "germ-psychoses." As I have already said, with these we do not find microscopic changes of the brain cells: neither do they lead to a terminal dementia (unless some other process occurs which has nothing actually to do with the psychosis itself). Also, there is a pronounced tendency towards recovery of individual attacks, but these attacks are liable to recur. Then there is this feature: many symptoms which are observed in this group are much more plausible and understandable to the untrained onlooker than so many of the

"organic" symptoms. As a matter of fact, many symptoms are recognisable as morbid exaggerations of slight peculiarities and moods, such as most of us possess. For example, a wild maniacal excitement may be considered as a pathological and distorted exaggeration of irresponsible cheerfulness, and all intermediate stages between these two can be observed in different patients. There are also all kinds of transition between the different disorders comprising this group. The principal representative is the condition known as "maniac-depressive insanity," which is characterised by psychotic explosions either of an abnormally elated or of an undue depressive nature, or both (either in succession or mixed). Furthermore, we distinguish paranoia and the graver forms of hysteria and other psychoneuroses. For my purpose of to-day, it is convenient to deal with all these conditions together.

The history of the development of these disorders varies in different patients: sometimes there does not seem to be any apparent outer cause at all, except the ordinary everyday vicissitudes of life, and the psychosis just develops; or there is a combination of factors at work which each by themselves would not seem strong or important enough; or there is one particular psychic cause which can be held responsible, be it in the nature of a shock, stress, or a conflict. But there is always the unmistakable personal element of the patient, a fault or an imperfection of his mental make-up. Hence the name germ-psychosis, which implies that the possibility or germ of the psychosis lies dormant in the personality of the patient; and we know that if a stronger, better-balanced mind had had to face the same circumstances, or had experienced the same conflict, he would have been able to cope with it and no psychosis would have been the result. Since Freud started his teaching we have heard a great deal about conflicts and psychic traumats, occurring in the realms of the three main kinds of human instincts, namely, the one for self-preservation, the one for race-preservation, and the herd-instinct. Of these three, the middle one, that of sex, in its widest sense, is surely not the least important.

Science is indebted for much that is true and useful in the psycho-analytical doctrines. More especially have they taught us to realise the necessity of approaching and treating psychic disturbances in a much more individualising manner than we did before, and to take into the fullest account the entire previous history of each patient. They have also shown the great harm which sometimes may be done if mental conflicts are not met squarely but are evaded and allowed to remain hidden in our minds and unsolved. On the other hand, numerous authors agree that the rôle of sex-complexes in the causation of neuroses and psychoses has been grossly overrated by Freud and specially by many of his followers. The experience gained during the late war has also shown that these conflicts may be of a very varying nature, and that if stress and trouble, in the widest sense, become sufficiently severe and prolonged, the very strongest minds may ultimately break down.

In dealing with this group of disorders we have, therefore, always to reckon with the reciprocal reaction between the personality of the patient and the circumstances he had to face. Prevention of the disease would be possible in a great number of cases if either the circumstances could be ameliorated, or if the power of the individual to meet and to cope with difficulties could be strengthened. There can be little doubt that the incidence of various kinds of mental disorders has increased considerably during the last century. I do not think it is possible not to ascribe this, at least partly, to the ever-increasing difficulties and complications of the economic relations in the world. We cannot hope to bring about effective changes in this economic evolution. But much good could be achieved if sound and expert advice were sought more regularly with regard to the careers to be followed by young people, and, if in individual cases, careers which are evidently unsuitable would be strongly advised against.

With regard to the strengthening of the individuals, I am convinced that much more could and ought to be done in the future than has been done in the past. Next to physical hygiene, we ought to study and to adopt the principle of personal mental hygiene. And where this would be of advantage even to the strongest and best-balanced minds among us, it becomes essential and of vital importance to those people, who, on account of peculiarities in their mental equipment, are possible candidates for functional disorders. Many of these peculiarities can be noticed already by careful observation in early life; and a more extensive and intensive study of child-mentality in the schools would ultimately yield most valuable results, and in many cases it might show the way to prevent a subsequent mental or nervous breakdown by means of individual guidance and special advice. It is also not impossible that in this manner we would succeed in the prevention of the development in some cases of schizophrenia.

It would lead me too far if I were to do more than to touch upon the vitally interesting subject of heredity. The older alienists already knew of its great importance. Although our knowledge has increased in some respects, still many doubtful points remain. For instance, it is at present not possible to assess approximately the chances there are for a certain individual with a tainted personal or family history of transmitting this taint to his children.

There is one condition, however, about which we are in a position to speak with much more knowledge and authority with regard to heredity, and that is mental defect. Here we know for certain, that in more than 50 per cent. this condition is due to faulty inheritance. If we succeed by means of segregation in not allowing the feeble-minded to propagate their defective species, the future incidence of this condition will decrease by over 50 per cent.

Summarising, we can say that if only effective measures could be carried out, in future all the psychoses due to drugs, alcohol and syphilis might be prevented. Further, a great part

of feeble-mindedness and of functional mental and nervous disorders and possibly a certain number of case of dementia præcox might be prevented. While we are endeavouring to attain this distant ideal, there is much that ought to be done immediately. The earlier psychoses are treated the more chance of success. Amongst the general public there is still much aversion against sending a patient to a mental hospital. In this way valuable time is often lost and the chances of recovery are prejudiced. There is a crying need for facilities of early and effective treatment of incipient cases in psychopathic wards, which should be a special department of general hospitals. The sooner the public in general realises the urgency of this necessity, the sooner we can hope for the establishment of such wards in at least some of our bigger centres.

Another great want is a substantial increase in the staffs of our present mental hospitals, and of more encouragement and facilities for research. Then, by the combined efforts of all the private individuals and the various authorities concerned, can we hope for a gradual increase of our knowledge of better and more effective treatment and of greater chances for prevention in future.

THE EARLY DEVELOPMENT OF SOUTH AFRICA.

BY

C. Graham Botha,

Chief Archivist for the Union of South Africa.

Summary of Public Evening Lecture, delivered July 13, 1922.

In speaking of the early development of South Africa we must not forget the deeds of the early navigators and the land pioneers. We are too apt to forget them, or not give them the high place to which they are entitled. We owe a great deal to them, and to-day we are sometimes inclined to look upon our progress with satisfaction, as if we were the sole actors, and to ignore what our forefathers have achieved. In many respects they have helped us to attain the place which we hold. It is a happy coincidence that this lecture is given in the country of our neighbours, the Portuguese. It is to them that, not only South Africa, but the world in general owes a debt of gratitude. By the deeds of their daring navigators towards the end of the 15th century an ocean route from Europe to India was opened. It was certainly one of the greatest events of the world's history. The names of Dias and da Gama should hold a prominent place in the history of South Africa. If we look at the names along our coast line we find reminders of those early days. The bays of St. Helena, Saldanha, St. Sebastian, Algoa were named by the Portuguese, as were most of the others, but some have changed with the passing of time. The Capes Agulhas, Vacca, St. Blaize and Recife are further evidences.

Little attention was paid to the southernmost portion of Africa for several centuries. After the Portuguese came Dutch and English navigators, who used the Cape of Good Hope as their half-way place of call on their way to the East. Except for an attempt two centuries ago by the English to possess themselves of the country by erecting their flag on the heights rising above Table Bay, no serious steps were made to take physical possession of the land until 1652. The Dutch East India Company saw the possibilities of establishing a permanent refreshment station on the shores of Table Bay. They were not aiming at setting up a colony, for colonisation was not a part of their programme. But gradually the country became during the early part of the 18th century a flourishing agricultural colony, and this movement could not be stayed by them. The dangers, trials and tribulations which the 18th century colonists endured should give them also a high respect in our history. As in most new countries inhabited by natives, and, for that matter, by wild animals, life was not altogether a bed of roses. The Company was at first satisfied to supply its garrison and the fleets touching here with the cattle bartered from the natives and the produce of the soil which they worked themselves. In course of time they found this to be unsatisfactory and expensive, and encouraged colonists to settle

here. The first colonists, who were for the most part farmers, were their own discharged servants whose term of service had expired. Towards the end of the 17th century they had handed over to the farmers all agricultural pursuits and looked to them to supply their needs.

The farmers were required now to produce not only for their own livelihood, but for a market as well. This necessitated more ground. Land was plentiful, but for those who carried on stock farming it was necessary to seek fresh pastures in times of drought or when the land had become barren. This meant a constant moving from one spot to another. The corn and the wine farmers were more settled, but the other type moved at first towards the north-west and after the first quarter of the 18th century towards the south-east, along the coastal belt. Immigration had stopped shortly after the first decade of the century, and up to this period it might be looked upon as the period of settlement, after which came the period of dispersion. This expansion was not at all what the authorities desired. They were anxious to keep the colonists in close touch with headquarters at Capetown; they did not desire them to get in too close contact with the natives for fear that their own trade with them would be lost. But, try as they would, they could not hold back the onward movement. Precautions were taken by military outposts, which served not only to keep the colonists within bounds, but also to aid them in case they were attacked by the natives. The people moved on and the Government followed.

The system of land tenure was, perhaps, a contributory cause of this expansion. Except in the more settled parts of the colony, as the Western Province, where many farms were granted in freehold, each farmer held his land on "loan." He chose a suitable area and applied for permission to remain there. This was granted, but every year he had to renew this permission. If he found the place unsuitable he moved further afield and went through the same process. Sometimes he had several "loan" places. His legal right to the ground was nil, for it belonged to the Company, which could resume occupation at the end of the lease. In this case the farmer was compensated for any buildings he had erected, and these were the only assets he could sell or transmit to his heirs. By the end of the Company's rule in 1795 they had expanded to the Great Fish River, which for many generations was the colonial boundary. From this stock of colonists, who had lived more or less a nomadic life, sprang the Voortrekkers, who more than eighty years ago moved out of the Colony and founded the Transvaal and Orange Free State Republics. They had the spirit of their forefathers to move forward and penetrate into unknown country inhabited by hostile natives and infested with wild beasts.

While the stock-breeder was pushing his way through unknown and uncultivated country, enduring hardships from the depredations of the Hottentots and the Bushmen, some attention was given to other branches of farming. The corn and wine farmer was producing for the market of the Company. The

Company itself was making experiments with the growing of tobacco, hemp, flax, indigo and cotton, and encouraged the farmers to grow olives. Whether through inertia to continue these experiments or not having a sufficient knowledge of the soil and climatic conditions, it is certain that many products which flourish to-day failed to give the Government encouragement to persevere. The two Governors van der Stel made every effort to encourage tree planting, as they observed that the indigenous forests were rapidly becoming denuded. A wise regulation required everyone who felled a tree to plant an oak in its place. Many of the freehold grants of land stipulated that the grantee was to plant annually at least one hundred oak trees on his property.

There was one drawback to the development of this agricultural colony—there were no roads or bridges to speak of. A little more than three-quarters of a century ago this defect was partly remedied. Distances from Capetown, the only market for the farmer of the 18th century, were great. The means of transport from the outlying places were by ox wagon. The roads traversed were little more than beaten tracks. The mountain barriers crossed were steep and dangerous and in some cases required several days to pass. Both man and beast suffered and ran the danger of losing their lives in passing over the rough track, over boulders and inclines on these mountains. Towards the middle of last century an earnest attempt was made to have proper lines of communication constructed in various parts of the country by making use of convict labour.

The establishment of a Central Road Board soon justified itself. Places which before were inaccessible became easier to reach. Attention was now given to fertile areas, which the farmer had not cared to cultivate because of his distance from and the trouble to reach a market. Villages were, as it were, brought nearer to the farmers on account of good roads, and they in turn were in close communication with neighbouring places. Hamlets, villages and towns began to spring up in succession. In short, the construction of better lines of communication and the bridging of rivers brought prosperity and progress to the colony. The crossing of unfordable rivers which, in the rainy season, kept the traveller for days on the one side before he could get over had made travelling tedious, dangerous and long. All this was overcome by properly constructed bridges.

But a new era was to add to this progress. The introduction of the railway, half a century ago, meant much for the country. While the extension of the railway line was at first very slow, nevertheless, it gave a means by which the farmer could get his produce to a market in a shorter time and with less risk and inconvenience. It is interesting to compare the lines of communication as opened by the early Dutch explorers during the 17th and 18th centuries with those by the railway line nearly two centuries later. The Dutch East India Company was not slow in sending out men to examine the country to ascertain its trade possibilities, as well as to get a knowledge of the natives, its geographical features and its mineral wealth. Most of the early expeditions

seem to have been sent out towards the north-western part of the Colony. The route between the present places Piquetberg, Clanwilliam, Van Rhynsdorp and Garies, right up into the South-West Territory, were well known after the middle of the 18th century. Attention was also given to the south-eastern parts. These routes prepared the way for the farmers, who in the early years of their migrations went first towards the north-west and, as remarked before, went over the Hottentots Holland Mountains towards the south-east during the early part of the 18th century. But the development of the railway route appears to have been the reverse. From Capetown it went in its early years across the Karoo to Beaufort West and, at the same time, was extending up from Port Elizabeth through the Eastern Province, with a branch line here and there. Within more recent times it has crossed the Hottentots Holland range over Sir Lowry Pass and extends beyond Caledon, while another line from Worcester goes down towards Mossel Bay and continues along the south-east coast through what is now known as the Garden Route. The north-west towards Van Rhynsdorp, which route was the earliest attempted by the 17th century pioneers, has only within very recent years had attention given it and the railway extended in that direction.

While the country was progressing another factor made its appearance, which was greatly to help in its developing process. This was the discovery of diamonds and gold. That the country was possessed of minerals was a fact which seemed evident to the early settlers. As far back as the days of van Riebeeck efforts were made to see what fruits the earth would yield. Mining operations on a small scale, the mere scratching of the surface, were carried on in the mountains and hills of the Cape Peninsula. Two places named the *Zilver Myn*—Silver Mine, one at Noordhoek and the other in the Simonsberg, along the Drakenstein Valley—are reminders of early attempts at mining. At both places the shaft sunk is still to be seen. The latter, however, was a "salted mine," for which the perpetrator of the deed was banished from the country. About the middle of the 18th century a number of men obtained from the Dutch East India Company the right to carry on prospecting for minerals along the mountain ranges within fifty miles of Capetown. At the beginning of the same century there were reports of coal having been found near French Hoek. It was not until 1867, when the diamonds were discovered, and 1886, when the Witwatersrand gold mines were opened, that past hopes were realised. The discovery of diamonds opened the third period of immigration in South Africa. Reference to the first period has already been made. The second was in 1820, when the British settlers came out. With this last period men poured in from all parts of the world. Soon a mining city arose on the waste veld of Griqualand West. The opening up of the Rand gold fields added greatly to this new era. From this time the development of the country became more pronounced than before. The federation of the Colonies of the Cape and Natal and the Republics of the Transvaal and Orange Free State had been mooted. Events were moving onward to the culmination of Union in 1910.

LIST OF PAPERS READ AT SECTIONAL MEETINGS.

Section A.—Astronomy, Mathematics, Physics, Meteorology, Geodesy, Surveying, Engineering, Architecture and Irrigation.

MONDAY, JULY 10, 1922.

1. Presidential Address on "The Rôle of Astronomy in the Development of Science," by M. A. Peres, D.Sc.

TUESDAY, JULY 11.

2. The Waterworks Department of the Antofagasta (Chili) and Bolivia Railway Company: R. H. Fox, A.M.Inst.W.E.

Section B.—Chemistry, Geology, Metallurgy, Mineralogy, and Geography.

TUESDAY, JULY 11.

1. Presidential Address on "The Influence of Mineral Deposits in the Development of a Young Country," by E. T. Mellor, D.Sc., F.G.S., M.I.M.M.

MONDAY, JULY 10.

2. Investigation of Different Methods of Testing Babcock Milk Bottles: B. J. Smit, B.A.
3. Notes on the Chemical Control of Cattle-Dipping Tanks: C. O. Williams, B.Sc., A.R.C.S.

TUESDAY, JULY 11.

4. Descloizite from South-West Africa: P. A. Wagner, Ing.D., B.Sc.

Section C.—Botany, Bacteriology, Agriculture and Forestry.

WEDNESDAY, JULY 12.

1. Presidential Address on "Carbon Assimilation," by D. Thoday, M.A.

TUESDAY, JULY 11.

2. The Pepper Tree (*Schinus molle*) as a Cause of Hay Fever in Bloemfontein: G. Potts, B.Sc., Ph.D.
3. The Measurement of the Hydrogen Ion Concentration in South African Soils in relation to Plant Distribution and other Ecological Problems: J. W. Bews, M.A., D.Sc., and R. D. Aitken, M.Sc.
4. The Effect of Slope Exposure upon the Climate and Vegetation of a Hill near Maritzburg; a preliminary investigation: R. D. Aitken, M.Sc.
5. The Composition of Some Indigenous Grasses: A. J. Taylor, B.A., A.I.C.
6. A Note on Suggested Methods of Preserving Fruits in vacuo and in Inert Gas: Bertha Stoneman, D.Sc.

Section D.—Zoology, Physiology, Hygiene and Sanitary Science.

WEDNESDAY, JULY 12.

1. Presidential Address on "Some Modern Developments in Animal Parasitology," by Annie Porter, D.Sc., F.L.S.

MONDAY, JULY 10.

2. A Note on the Occurrence of *Aphelenchus phyllophagus* in Chrysanthemums in the Transvaal, with Suggestions for its Control: J. Sandground, M.Sc.
3. The Influence of the Cooling Power of the Atmosphere on the Rate of Growth of Young Animals: E. H. Cluver, M.A., M.D.
4. On the Incidence of Keratomalacia among Rats suffering from Avitaminosis: A. D. Stammers, B.A.
5. The Blood of Equines: C. P. Neser, D.Sc., M.R.C.V.S.

TUESDAY, JULY 11.

6. Observations on the Development of the Non-Aquatic Tadpole of *Anhydrophryne rattrayi* Hewitt: E. Warren, D.Sc.
7. The Origin of Feathers from Scales: J. E. Duerden, M.Sc., Ph.D.
8. Degeneration in the Limbs of South African Serpentiform Lizards (*Chamæsaura*): J. E. Duerden, M.Sc., Ph.D., and R. Essex, B.Sc.
9. A Curious Case of Veterinary Clinic Practice: M. Prates, M.D., and S. Pinto.
10. Some Molluscan Inhabitants of the Natal Lagoons: F. G. Cawston, M.D.

THURSDAY, JULY 13.

11. Variation in the Tenth Rib of the Penguin, *Spheniscus dermersus*: J. E. Duerden, M.Sc., Ph.D., and V. FitzSimons, B.Sc.
12. Metallic Suturing of Bones in the Case of Fractures: L. Soromenho, M.D.
13. Economic Entomology in Moçambique and its Problems: C. B. Hardenberg, M.A.
14. Estudo sobre as bebidas alcoolicas cafreaes fabricadas pelos indigenas da Provincia de Moçambique: L. Soromenho, M.D.
15. Contribution to the Study of Human Parasitology in Moçambique: M. M. Prates, M.D.
16. Contribuição para o estudo da patologia ocular de Moçambique: M. M. Prates, M.D.
17. On the Zoological Evidence relating to Ancient Land Connections between Africa and Other Portions of the Southern Hemisphere: J. Hewitt, B.A.
18. Some Parasitic Protozoa found in South Africa—V: H. B. Fantham, M.A., D.Sc.
19. Some Protozoa found in certain South African Soils—II: H. B. Fantham, M.A., D.Sc., and Esther Taylor, M.Sc.

Section E.—Anthropology, Ethnology, Native Education, Philology and Native Sociology.

THURSDAY, JULY 13.

1. Presidential Address on "Certain Aspects of the Native Problem," by Senator A. W. Roberts, D.Sc., F.R.S.E.

MONDAY, JULY 10.

2. Hottentot Place Names—II: Rev. Chas. Pettman.

TUESDAY, JULY 11.

3. A Selection of SiRonga Proverbs: Rev. H. L. Bishop, F.R.A.I.
4. A Selection of SiRonga Folklore: Rev. H. L. Bishop, F.R.A.I.

WEDNESDAY, JULY 12.

5. The intervocalic "N" and "L" in Old Portuguese, and the rise of Portuguese Nationality: Madame D. Victoria Batista de Sousa Ribeiro Gomes.

THURSDAY, JULY 13.

6. The Descriptive Complement in the SiRonga Language, compared with that in Sesotho and in Zulu: Rev. H. L. Bishop, F.R.A.I.
7. Dr. Theal and the Records of South-East Africa: Rev. W. A. Norton, M.A., B.Litt.
8. The Philology of the Romance Languages, illustrated especially from French and Portuguese: Rev. W. A. Norton, M.A., B.Litt.
9. A Glossographic Map of South Africa: Rev. W. A. Norton, M.A., B.Litt.

Section F.—Education, History, Mental Science, Political Economy, General Sociology and Statistics.

THURSDAY, JULY 13.

1. Presidential Address on "Remarks on Certain Mental Disorders which may be regarded as Preventable," by J. Marius Moll, M.D.

TUESDAY, JULY 11.

2. The Early History of the Cape Province as illustrated by Dutch Place Names: C. Graham Botha.

THURSDAY, JULY 13.

3. An Introductory Outline of Some of the Practical Applications of Modern Psychology: F. S. Livie-Noble.

FRIDAY, JULY 14.

4. A Note on Some Australian Proposals for a Wage varying in proportion to the Size of the Family: Mabel Atkinson, M.A. (Mrs. Palmer).
5. The Present Currency Problem in Moçambique: Capt. Auguste Cardozo.

THE WATERWORKS DEPARTMENT OF THE ANTOFAGASTA (CHILI) & BOLIVIA RAILWAY COMPANY

BY

ROBERT H. FOX, A.M.INST.W.E.
Chief Engineer, Waterworks, Delagoa Bay.

With Plate I.

Read July 11, 1922.

HISTORICAL.

The Antofagasta (Chili) and Bolivia Railway is now a long international line, which has grown from small beginnings as a narrow gauge mineral railway—22 miles long—into an important undertaking, linking the interior of Bolivia with the Pacific Coast, and with a total length of 1,216 miles.

Antofagasta, which is situated on the coast 30 miles south of the Tropic of Capricorn, was originally the Bolivian port on the Pacific but was captured by Chili in the war between the two countries in 1879, since when Bolivia has been without any sea coast.

The railway line was first commenced in 1886, to bring down nitrate earth for elaboration in the works in the port into nitrate of soda. The early fields giving out, the railway was carried farther into the interior of the country after the valuable earth, and eventually reached Kilometre 144, where for a considerable period the line terminated.

The region where nitrate earth is found, is a belt some 52 kilometres wide, which roughly parallels the coast at a distance of about 100 kilometres. It should be here stated that this belt forms part of the Desert of Atacama, and that from the coast to the highest point of the railway where it crosses the cordillera of the Andes at a height of 13,000 feet, there is *no* rain.

Since the early days, and with the provision by the railway of abundant water, it has been found much more economical to elaborate the nitrate earth on the fields where it is obtained, rather than erect more works in the port; and at the present time there are 23 nitrate works, or "oficinas" as they are called, on the line of railway and within the belt already mentioned.

At Kilometre 170 the nitrate district is passed, but the railway was carried on towards Bolivia under the auspices of the Huanchaca Company for the purpose of bringing down the valu-

able silver ores extracted from their famous mines at Pulacayo in Bolivia, some 630 kilometres from the coast and situated at an altitude of 12,500 feet above sea-level.

From there onward, the continuation to Oruro—an old seat of the Bolivian Government—and La Paz, the present capital, was an assured conclusion.

The country traversed by the railway is desolate to a degree. For a distance of 438 kilometres to the Bolivian frontier, only one river is encountered—the Loa—which is crossed by the railway at Kilometre 238 and again at Kilometre 300, and a tributary of the same river—the San Pedro—at Kilometre 313.

Apart from these, in the whole of this distance not a single stream, spring or brook is to be found on the surface. The Railway Company, therefore, at the commencement, had to depend on distilled water obtained from sea water distillers in the port.

With the extension of the line into the interior this became a matter of increasing difficulty, and with the growing needs of the town which was springing up around the works in the port, it was obvious that some other supply was necessary.

The water in the river Loa is very heavily charged with salts, and is quite unsuitable for human consumption or locomotive boilers, and so it was necessary to go still farther afield.

In 1888 the railway line had reached San Pedro, and at this point crosses a tributary of the river Loa, called the San Pedro River, which rises at the base of the volcano San Pedro, some 30 kilometres from the railway line.

The water in this stream has a hardness of 26 degrees, but notwithstanding, the Railway Company decided to apply for a concession from the Government to take water from the stream, and to carry the same in pipes to Antofagasta for the use of the community, and the railway shops which were installed there. From that date the Waterworks Department came into being.

The concession was duly obtained, but the Government fixed the maximum price at which water could be sold for all time, and also stipulated for the free supply of water for municipal and government purposes to the towns en route and to Antofagasta.

In 1900, in order to improve the quality of the water supplied, the pipe line was carried on to some springs farther in the cordillera of the Andes, distant some 340 kilometres from Antofagasta.

In 1905, nitrate oficinas commenced to spring up in the nitrate district before mentioned, and a second pipe line, 204 kilometres long from San Pedro to Kilometre 110, to supply San Pedro River water for elaboration purposes in the oficinas was decided upon and the work put in hand. This was concluded in 1908.

At the end of 1908 the quantity of good water available for domestic and locomotive consumption was insufficient for the requirements and a pipe line from the Bolivian frontier to the

storage reservoirs in San Pedro, some 60 kilometres in length, to carry water suitable for domestic purposes was laid down in 1909/1910.

In 1911 the old pipe line from San Pedro to Antofagasta was found to be unable to deliver all the water required for the needs of the town, and it was decided to continue the No. 2 pipe line to the port, the work being completed in October, 1913.

This short historical review therefore brings us to the present date, and briefly recapitulates the growth of the undertaking.

Intakes and Storage Reservoirs.

There are four sources of supply from which the Company has the right to take water, viz.:—

San Pedro River	...	10,712 feet above sea-level
Palpana Springs	...	11,800 ,, ,, ,,
Polapi Springs	...	12,486 ,, ,, ,,
Siloli Stream ...	...	14,154 ,, ,, ,,

and all are being drawn upon. The latter three are all waters perfectly suitable for domestic and locomotive boiler consumption, but the San Pedro River is very hard and contains an excess of calcium carbonate, and on that account is only delivered to the nitrate oficinas for the boiling of the nitrate earth, where the quality of the water is negligible.

The following is a comparative analysis of the San Pedro River and Siloli stream waters.

Analyses made by Chilian Government analyst, Santiago.

	San Pedro River	Siloli stream
	(in parts per 100,000.)	
Silica	8·8	2·75
Iron oxide and alumina ...	1·2	·15
Potash and soda from chlorides	10·7	3·05
Chlorine	19·6	1·02
Lime	5·88	1·56
Sulphuric anhydride ...	4·55	·48
Magnesia	7·75	·86
Nitric anhydride	—	·15
Loss by calcination	16·00	3·00
Oxygen consumed by organic matter	·024	·068
Saline ammonia	·005	·00188
Albuminoid ammonia ...	·020	·0035

Mechanically suspended matter not measured.

	74·529	13·09
Total solids	85·00	13·00
Hardness, total ...	26°	5°
Hardness, permanent..	12°	4°

At Palpana and Polapi the springs are collected into a central chamber by means of covered channels, and the mains carry the collected water to San Pedro.

At Siloli a small dam has been built across the stream which has a daily flow (with very slight variations) of 11,300 cubic metres, or, say, 2,500,000 gallons. The draw-off for the main to San Pedro is carried through the dam. The author believes that this is probably the highest intake of any waterworks undertaking in the world, although the Department has charge of a small station supply on the Collahuasi branch of the railway, where the intake is at an altitude of over 15,000 feet.

On the San Pedro River, which at the Company's intake is in a narrow gorge, three contiguous chambers have been built across the bottom of the gorge, and the river passes into the centre chamber, and overflows a weir placed in the rear wall.

In the division walls between the chambers, weirs have been cut at a slightly lower level than the weir in the end wall, so that these chambers are always maintained full. The photograph (Plate I) shows the intake with the San Pedro volcano in the distance.

The storage reservoirs situated in San Pedro at a height of 10,680 feet above sea-level at Antofagasta are four in number, and have a total capacity of 28,000 cubic metres.

They are excavated in the solid rock, which, at this point, comes up to ground level without any earth covering whatever. They are rectangular in plan and the walls are made smooth and vertical with concrete. The draw-off arrangements have nothing unusual to remark upon.

It may be here mentioned that the rarefied atmosphere at these altitudes, and more especially at Siloli, renders exertion difficult. Mountain sickness generally overcomes British people, but the Bolivian Indian, who lives at altitudes between 12,000 and 17,000 feet, proves equal to the labour required in construction, and the amount of work which can be got out of him is surprising.

Pipe Lines.

The waterworks department of the railway is responsible for the water supply at all stations on the line, the sale of water in the towns of Calama and Sierra Gorda in the interior, and the ports of Antofagasta, Mejillones and Coloso on the coast, as well as the sale of water in bulk to the nitrate oficinas which are situated close to the railway.

The total population in the region served by the waterworks department is about 85,000.

The stations beyond the reservoirs in San Pedro are supplied from small independent works, by means of pipe lines carried into the hills, where small springs fed from the melting snow are sufficient to meet the locomotive and station requirements.

The main pipe lines are as follows:—

Name.	Length in miles	Size.	Discharge cb. mts. per day.
Polapi—San Pedro	17	8 inches.	1,800
Palpana—San Pedro	9·5	6 inches.	240
Siloli—San Pedro	35	11, 10, 9, 8 inches.	6,600
San Pedro—Antofagasta No. 1	194	300 millimetres 165 millimetres	2,500
San Pedro—Antofagasta No. 2	177	17, 14, 13, 12, 11, 10, 9½ inches.	8,400

The three first mentioned pipe lines deliver their waters to the storage reservoirs in San Pedro. From these the No. 1 and No. 2 mains are fed.

A section of the pipe lines from San Pedro to Antofagasta, and, indeed, from the intakes at Polapi and Siloli shows a continuous fall, without a reverse grade at any point. This is a remarkable feature of the main pipe line system, and in order to obtain pressure in the mains, inverted U legged standpipes have been fixed in the main, to enable the various supplies to be given and to avoid having to limit main valves.

The first main laid from San Pedro to Antofagasta was of cast iron pipe of French manufacture, with a joint known as the "acme" joint. This consists of a short socket with outside lugs for bolts. The spigot end carrying a rubber ring of square section is inserted, and a cast iron packing gland is bolted down on to the rubber ring expanding the same into a groove on the inside of the socket and making the joint water-tight.

This type of joint in the No. 1 main has rendered good service, and joints, which from various causes have been taken out, show very little deterioration. At the same time it must be borne in mind that the main is worked under very little pressure. On occasions when, by accident or mal-intentioned workmen in the nitrate district, a main valve has been closed, the joint has failed to stand where an ordinary leaded joint has not suffered.

The projecting lugs for the bolts on the socket end of the pipe are also a weak point, as with the rough handling almost unavoidable where sea transport comes into question, they are often broken off.

In order to limit the maximum head, the pipe lines are divided into sections varying in length, but with a maximum ruling head on the sections of 150 metres. At the end of each section a relief or break pressure tank, circular in plan, has been placed. This tank is constructed of riveted steel plates and has a diameter

of 10 feet and a height of 13 feet. It is set on a masonry foundation 3 feet above the level of the pipe line and has an inlet and an outlet in the base. It is fitted with an overflow pipe and also has a float indicator, so that the inspectors may note the amount of water in the tank.

The following table is the standard form employed in the department, giving the hydraulic data in connection with the design of new pipe lines and has reference to the Siloli pipe line construction in 1909/1910. The discharges are calculated from Thrupps formula.

$$Q = \frac{D^{2\cdot63}}{\cdot0209/S}$$

where Q = Discharge in cubic feet per second.
S = Cosecant of slope.
D = Diameter of pipe in feet.

Relief Tank.	Kilo-metres.	Free Surface Level.	Distance metres.	Difference of Level.	Hydraulic Gradient.	Pipe Dia-meter.
San Pedro	0	3255·69	metres			
No. 8	3,100	3383·72	3,100	128·03	4·13%	8 ins.
7	6,440	3514·14	3,340	130·42	3·91%	8 ,,
	8,460	3586·86	2,020	72·72	3·6 %	8 ,,
6	11,120	3637·13	2,660	50·27	1·89%	9 ,,
	12,600	3690·06	1,480	52·93	3·6 %	8 ,,
5	16,900	3777·31	4,300	87·25	2·03%	9 ,,
4	31,700	3883·82	14,800	106·51	·72%	11 ,,
	37,000	3921·28	5,300	38·16	·72%	11 ,,
3	43,050	3989·74	6,050	67·76	1·12%	10 ,,
	45,150	4065·34	2,100	75·60	3·6 %	8 ,,
2	48,900	4136·59	3,750	71·25	1·9 %	9 ,,
	51,200	4219·39	2,300	82·80	3·6 %	8 ,,
1	52,200	4238·39	1,000	19·00	1·9 %	9 ,,
	53,620	4290·84	1,457	52,45	3·6 %	8 ,,
Intake	55,870	4315·82	2,250	24·98	1·1 %	10 ,,

The designed capacity of the above main was 7,400 tons per day, and tests since made of the delivery have given results about 5 per cent in excess of this figure.

The No. 2 pipe line is laid with ordinary cast iron socket and spigot pipes from San Pedro to Kilometre 110 of the railway. The succeeding section from Kilometre 110 to Kilometre 59 was originally intended to be used as a high pressure main to free water over the crest of an intervening ridge between Kilometre 59 and Mejillones, and, as this would have necessitated a maximum working pressure of 507 lbs. per square inch and a maximum static head of 910 lbs. per square inch, exceptionally heavy cast iron flange pipes were employed. The diameter of the main is 10 inches and 9 inches and the 9-inch pipes are 1·2 inches thick. Under the maximum static head, the main has withstood the high pressure without loss. In the laying of this pipe line, the pipes were all 12 feet long, and in order to enable

pipe laying to proceed in different sections at the same time, expansion joints were employed in joining up the sections.

The proposed route to Mejillones was eventually discarded, and this main is now only worked as a low pressure main in common with the rest of the pipe line.

The Siloli main line is laid with socket and spigot lapwelded steel pipes of the following thicknesses:—

Inches.	Inches.
11	0·19
10	0·19
9	0·19
8	0·16

The main has been in service for twelve years and has given much less trouble than our ordinary cast iron mains.

One extraordinary case of rapid corrosion occurred which was somewhat disquieting, but a careful investigation of the causes of this was made and definite conclusions arrived at, and there has been no further trouble. The case of corrosion mentioned occurred at a joint, and, on examination, it was found that the pipe had been eaten through, both on the socket and through the part of the spigot where it left the socket. From the appearance of the metal, it almost seemed as if the pipe had fused. The pipe line at this point is laid in a bed of fine, hard gravel. Due to faulty workmanship a portion of the lead joint had blown out, and the issuing jet on the gravel had formed a kind of circular sand blast which had eaten rapidly through the steel.

It is not quite certain how long this had been going on, but the main had been in operation for only one year, and it is possible that the leak from the joint had been going on for that length of time.

When designing the extension of the No. 2 main to Antofagasta in 1910, advantage was taken of a short cut through the hills to deviate from the railway line and save a distance of 17 miles. This, of course, was not possible with the first pipe line which had to follow the route of the railway for purposes of supply to the stations.

In the last five miles of the route of the second pipe line, there is a drop in level of 1,410 feet and it was felt that advantage should be taken of this head to drive a Pelton wheel for the generation of electric energy, which would be placed at the inlet to the new reservoir which forms part of the scheme.

The main was, therefore, designed with this object, and 11 inch lapwelded steel pipes with loose flanges and a thickness of 0·35 of an inch were laid down. It should be here noted that the required discharge of the main to Antofagasta was only 3,500 cubic metres per day, but by the use of 11 inch pipes the maximum head available is made use of. Flat india-rubber rings in a flat seating are used in making the joints between the flanges of the pipes.

A full pressure test of 610 lbs. per square inch was made on this main, and both pipes and joints have stood admirably.

Service Reservoirs.

With the exception of a new covered concrete reservoir at Antofagasta the storage of water is effected by means of steel plate tanks.

Each water station has a square steel tank erected on a steel girder trestle for the locomotive and station supply. The tanks are built up from 4 feet square pressed steel plates with the edges turned up to form a flange. The tanks are 24 feet square and 8 feet high and have a capacity of 28,600 gallons The plates are bolted together on the outside, and a strip of sheet lead is inserted between the flanges projecting ½ inch outside the interior face of the tank. This is afterwards caulked down and fills the joint, making it watertight.

At Kilometre 170, before reaching the nitrate district, two large riveted steel tanks, circular in plan and with a capacity of 660,000 gallons each, have been erected. Nos. 1 and 2 mains deliver into these, and they act as storage and balancing tanks.

At Antofagasta until 1915, storage was carried in seven circular riveted steel plate tanks of the following capacities.—

2 of 96,800 gallons
2 of 517,000 gallons
3 of 398,200 gallons

or a total storage of 2,422,200 gallons, equal to four-and-a-half days' supply. Steel tanks were doubtless originally decided upon on account of earthquake shocks which frequently occur, and also because of the difficulty of obtaining good workmen in masonry and concrete in the earlier days.

The steel tanks after cleaning are coated with a cement wash and this has preserved the plate from corrosion.

Since 1909 there has been a rapid increase in the average daily consumption, and increased storage capacity for the town supply became a necessity. A circular concrete covered reservoir of 2,200,000 gallons capacity was designed and appproved, and the work of construction was commenced in April, 1913. It was successfully completed and filled in August, 1914. A steam-driven concrete mixer was used, which resulted in a far better quality of concrete than could have been counted upon had Chilian hand labour been employed. The cement was imported from England in barrels and cost £3 15s. 7d. per ton placed on the site. The stone taken out of the excavation was very poor in quality and partially decomposed and was not good enough for the concrete, but fortunately good stone was found at a distance of a kilometre. The concrete in the floor and walls was composed of:—

4 parts of stone, crushed to 2½ inch ring.
2 parts sand.
1¼ parts cement.

The old rails intended for the floor were dispensed with as a good rock foundation was encountered. Instead of using rails for the reinforcement of the columns, four 1 inch steel bars set at 10 inch centres were used, and wrapped round with No. 8 L.W.G. steel wire at intervals of 9 inches. The interiors of the reservoir and the columns were rendered with $\frac{3}{4}$ inch of cement and sand in equal proportions.

The valve house has been erected with a view to placing the Pelton wheel on the roof of the reservoir, and installing the electric plant in the upper storey of the building, but as yet this part of the scheme is in abeyance pending more favourable time for capital expenditure.

The valves in the valve house are worked by means of head-stocks, and the high pressure valves on the inlet main are provided with 3 inch bye-passes.

Water Distillers.

In 1905 the Company decided to instal two sets of water distillers in Antofagasta in order to act as a safeguard in case of serious accident to the main pipe line, which would have left the town absolutely without water. Two sextuple sets of Messrs. Fawcett, Preston and Co.'s distillers were obtained, each with a capacity of 44,000 gallons per day.

These are erected on the sea shore about three miles south of the town. Each set consists of six evaporators, heater, condenser and pumping engine, and there are three Lancashire boilers, 8 feet in diameter and 30 feet long, common to the two sets.

The pumping engine carries the air pump, two circulating pumps, the distilled water discharge pump, and the brine discharge pump for withdrawing the brine from the pans.

The evaporators consist of steel drums, 6 feet 6 inches diameter and 12 feet high. The lower part of the drum contains a steam chest with vertical copper tubes.

Salt water from the main condenser is passed through a Green's economiser and is admitted to the first evaporator pan. Exhaust steam from the pumping engine at 9 lbs. pressure is passed to the steam chest around the condenser tubes in the lower portion of the pan. Part of the salt water is thus evaporated and the steam raised (which has a pressure of about 6 lbs.) passes to the steam chest of pan 2. The salt water having increased in temperature is also fed into the evaporation chamber of this pan, and again partially converted into steam. This process is repeated throughout the set, and the concentrated brine in the last pan is discharged through the brine pump. The condensations from the steam chests of the first three pans are led back to the boiler feed, whilst the condensation from the last three pans pass to the main condenser. A complete system of bye-passes on all pipes and mains enables any pan to be cut out of the set for cleaning without necessitating the stoppage of the whole plant. The incrustations in the tubes of the evaporators

are got rid of by hand scraping, each pan having a manhole for access. The bottom of the pan which is of cast iron can be lowered to enable the scale to be taken out. The incrustation is most heavy in the first three pans and these require cleaning every two months. The last three are cleaned out once in three months. The steam pressures and vacua in the pans are as follows:—

	Steam Chest.	Vapour from Evaporation.
Pan No. 1.	9 lbs.	6 lbs.
,, 2	6 lbs.	3 lbs.
,, 3	2 inches vacuum	3 inches vacuum
,, 4	3 inches vacuum	9 inches vacuum
,, 5	9 inches vacuum	16 inches vacuum
,, 6	16 inches vacuum	25 inches vacuum
Main condenser vacuum	27 inches.	

The ratio of water produced per ton of coal burnt has reached as high as 30 : 1, but this is entirely dependent on the class of coal used.

Welsh coal gives about	30 : 1
Patent fuel (briquettes)	26 : 1
Australian coal	23 : 1

Steady firing and careful attention are important factors which will considerably affect the ratio obtained.

The adjacent port of Mejillones, distant some 70 kilometres from Antofagasta, and which is another coast terminal to the railway, is not yet supplied with water from the main pipe lines, although a scheme has been approved and the materials ordered for a new main to the port. Two further sets of Fawcett, Preston and Co.'s distillers have been erected there, and have now been under continuous daily work for seven years. They are exactly similar to the Antofagasta sets but a recent change has been instituted whereby the boilers are fired with oil fuel. The system of oil burning employed is the Wallsend-Howden—a pressure jet system. The oil from the storage tanks flows to a pump chamber and is pumped through a heating cylinder, heated by means of live steam from the boilers. The oil at varying pressures of 75 lbs. to 150 lbs. is fed to the burners, and passing through a diaphragm inside the nozzle is very finely atomised. The construction of the burner is such that the issuing jet is conical in form, and the heat is therefore applied equally to the whole interior surface of the furnace. The results obtained from the use of oil fuel have been extremely satisfactory, and the ratio of water produced per ton of fuel burnt has increased to 36 : 1.

The oil fuel is a residuum oil obtained from California and has a heat efficiency of 18,000 B.T.U. As the prices of coal and fuel oil in Antofagasta are practically the same, and only two attendants are required for the furnaces where previously eight were employed, the economy is very marked.

Methods of Distribution and Control.

The headquarters of the department are in Antofagasta, and sectional engineers are stationed in Calama and Mejillones, and there is also a branch office in Central, which is in the centre of the nitrate oficina district. The care of the intakes and storage reservoirs and the maintenance of the pipe lines are carried out by a permanent staff stationed at convenient points, and, as the pipe lines run parallel to the railway, inspection work is greatly facilitated. Venturi meters are employed to measure the water leaving San Pedro, and others are placed on the mains, at Calama, Central, and Antofagasta, By this means and from the fact that all supplies from the main are metered, it is possible to check up and account for any loss on the various sections.

The nitrate oficinas, which are practically small towns, with populations varying between 1,000 and 3,000 people, are supplied with water in bulk to their pumping stations, as they are all situated above the hydraulic gradient of the mains. From there it is pumped to the storage tanks in the oficina through their own mains, which vary in length from one to five miles.

Three-inch Worthington meters are used for measuring these supplies, as well as for the railway station supplies.

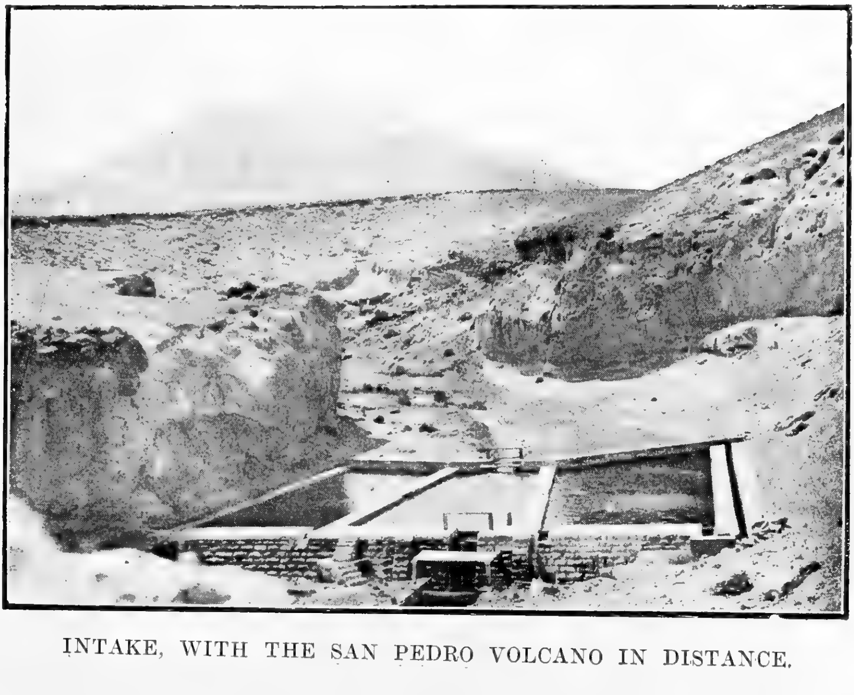
The delivery through these meters varies between 1,000,000 and 2,000,000 gallons per month. When working at this latter figure, the brass liners of the cylinders of this meter speedily become worn and at the end of 6 months a meter has been observed to be as much as 12 per cent. to 14 per cent. slow. Testing chambers, therefore, have been built in concrete alongside the meters for the oficina supplies, and periodical tests are carried out on these meters, and faulty ones changed without delay. Although this arrangement of having testing chambers and pipe connections alongside each meter installation may seem somewhat extravagant, when it is realised that the price for water sold to oficinas is 4s. 6d. per 1,000 gallons and that some of them consume 3½ million gallons a month, the expense entailed in making the testing arrangements is speedily recovered from the extra revenue derived by the use of accurate meters.

In Antofagasta water is supplied to consumers at the rate of \$1·40 (Chilian) per cubic metre. The sterling value of the Chilian peso has fluctuated between 14d. and 6½d. during the last eight years, the latter figure being the present rate (July, 1922.)

Galvanised iron service pipes are employed in Antofagasta with ⅜ inch and ½ inch Kent's Standard meters in general use for domestic supplies, and the meter rents are as follows:—

⅜ inch meter	... ...	4s. 3d. per month.
½ ,,	... ...	4s. 10d. ,,
¾ ,,	... ...	5s. 5d. ,,
1 ,,	... ...	7s. 3d. ,,

Agreements for water services are only entered into with the owner of the property, as there is no law making it compulsory to instal fresh water services in every dwelling house. Occupiers



INTAKE, WITH THE SAN PEDRO VOLCANO IN DISTANCE.

To face page 130.

of waterless houses obtain their supply from water sellers who can buy at public water posts maintained by the Railway Company in various parts of the town, and who hawk the water in wooden tank carts. Water accounts are rendered monthly, and are, as a rule, collected from the tenant of the house supplied, but the owner of the property is held responsible for payment.

A complete meter repairing workshop with small machine tools driven by electric power is maintained by the department in Antofagasta, where about 50 meters per month are changed, tested and repaired.

A system of Deacon waste water detection meters has been installed and systematic testing and inspection is carried out with the object of reducing loss to a minimum.

The water entering the service reservoirs, and also the delivery from them to the town is measured by Venturi meters, and it is possible to obtain definite information as to the water unaccounted for over the system, the amount varying between 5 per cent. and 9 per cent.

An electric indicating and registration cabinet has been placed in the head office in Antofagasta, and to this the inlet and outlet Venturi meters and the water level transmitters on the six reserve tanks are connected. Transmission is effected by means of single line telegraph wire, the transmitters working through a split battery, the recorders in the cabinet being operated by means of polarised relays. The levels of the water in the tanks at any moment are indicated on the circular dials in the cabinet, whilst the drum below carries a weekly diagram showing the fluctuations in each tank. The Venturi meter transmitters also actuate a dial face, which synchronises with the meter in the valve house, and, in addition, records on a diagram the rate of flow. The line traced on the diagram at the meter is actually the crest of the shaded portion recorded on the diagram in the office cabinet.

The author fears there is little to be learned from the foregoing brief description of a somewhat unusual waterworks undertaking, but hopes that it may be of interest to the Members of the Association.

INVESTIGATION OF DIFFERENT METHODS OF TESTING BABCOCK MILK BOTTLES.

BY

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Read July 10, 1922.

The usual quick method of testing Babcock Milk Bottles used in the Cedara Laboratory is a volumetric one, but before finally rejecting any particular bottle as being outside the limits of error allowed, it has been usual to carry out a confirmatory test by a gravimetric method, using either water or mercury. Having found in several instances serious discrepancies between the two sets of results, I decided to investigate the matter further in order to see what differences one would expect in results obtained by the different methods of calibration, when only taking the ordinary amount of care and observing the usual precautions in each case.

The following details are given of the three methods of calibration employed.

I. Volumetric Method.

For this method, 1 c.c. standard graduated pipettes are used, which have been carefully calibrated by running their contents of distilled water into a bottle and weighing, after allowing to drain for three minutes, and then carefully blowing out the last drop. The calibration of each pipette was done for the whole 1 cc. and the error in delivery was found to be fairly constant under the conditions of working, being 0·008 c.c. This gives a correction of 0·08 per cent. over a range of 10 per cent. on the Babcock scale for milk bottles.

When testing, the milk bottle is first filled with water exactly to the zero mark, and the neck carefully dried with a roll of blotting or filter paper. Then the contents of the graduated pipette up to 0·8 c.c. are carefully run into the neck of the bottle allowing the pipette about three minutes to drain into the bottle. At the end of that period the last drop is blown out, and the reading on the neck taken, adding a correction of 0·03 per cent. This is repeated, and the reading then taken for the whole range of the scale (that is, 8 per cent.), allowing now 0·06 per cent. as a correction.

It is realised that the result of the calibration of the lower half of the graduated scale is vitiated somewhat by the fact that a small proportion of the water run in clings as a film on the top half of the neck.

II. Gravimetric Method, using Distilled Water.

The bottle is filled up to the zero mark with water, the neck dried carefully as in Method I, and the bottle then weighed. Next, water is added to exactly the 4 per cent. mark, and the bottle and contents again weighed, this being repeated by pouring water up to the top of the scale, care being taken in each case to have the neck above the water level as dry as possible. From the weight of water added each time, and the temperature, the exact volume is found, and this is converted into percentages. In this way, the error up to the 4 per cent. mark, and also for the whole scale, is obtained.

III. Gravimetric Method, using Mercury.

In this method, mercury is run in from a separating funnel up to approximately the zero mark, the exact reading being taken by means of a table cathetometer, and the bottle weighed. Mercury is next run in to approximately the middle graduation (4 per cent.), and finally up to approximately the top graduation (8 per cent.), the weight run in being ascertained in each case. The error in the graduated scale is then obtained (as in Method II) for approximately the bottom half and over approximately the whole scale.

The errors in the graduated scale at these two points, obtained by each of the above methods for ten bottles, are given in the following table. The error is taken to be a negative one when the true reading is less than the apparent one on the scale.

On comparing the results (see Table) obtained by the various methods it will be noticed:—

1. Duplicate results by the volumetric method compare fairly closely as a rule, but those obtained by the two gravimetric methods are rather erratic, especially some obtained by the third method (using mercury).

2. The results obtained by the second method are uniformly lower than those obtained by the other two methods, thus causing, in these particular bottles, the errors (being negative) to be greater than those obtained by the other methods. This may possibly be explained by the initial weighing in the second method being generally too high, owing to the film of moisture left on the neck of the bottle in spite of the precautions that were taken to wipe off the superfluous moisture previously. In most cases, the mean errors obtained by the first and by the third methods compare fairly well.

The lack of concordance in the results obtained in repeated calibrations of the same bottle, especially by the two gravimetric methods, may be due to any of the following sources of error in working:—

1. The closeness of the graduation marks: The distance between each line (equivalent to 0·1 per cent.) is less than 1 mm. in length, so that it is very difficult to read to a close approximation of the second place of decimals, even by the use of a table cathetometer.

Comparison Table.

	ERRORS IN GRADUATIONS (Method I).				ERRORS BY METHOD II.				ERRORS BY METHOD III.			
No.	No. of Tests.	Minimum.	Maximum.	Mean.	No. of Tests.	Minimum.	Maximum.	Mean.	No. of Tests.	Minimum.	Maximum.	Mean.
1	2	—0·05 —0·13	—0·09 —0·15	—0·07 —0·14	4	—0·09 —0·17	—0·13 —0·22	—0·11 —0·19	5	—0·04 —0·06	—0·12 —0·21	—0·07 —0·12
2	2	—0·03 —0·12	—0·03 —0·11	—0·03 —0·12	4	—0·10 —0·18	—0·13 —0·23	—0·11 —0·21	5	—0·00 —0·05	—0·09 —0·14	—0·03 —0·09
3	2	—0·04 —0·16	—0·05 —0·16	—0·05 —0·16	5	—0·05 —0·15	—0·13 —0·24	—0·10 —0·20	4	—0·02 —0·03	—0·08 —0·18	—0·06 —0·10
4	2	—0·04 —0·11	—0·07 —0·11	—0·06 —0·11	4	—0·09 —0·15	—0·12 —0·21	—0·11 —0·19	2	—0·09 —0·10	—0·11 —0·13	—0·10 —0·11
5	2	—0·10 —0·18	—0·06 —0·20	—0·08 —0·19	3	—0·09 —0·24	—0·11 —0·28	—0·10 —0·26	2	—0·08 —0·17	—0·09 —0·21	—0·09 —0·19
6	2	—0·13 —0·22	—0·09 —0·22	—0·11 —0·22	4	—0·12 —0·23	—0·14 —0·24	—0·13 —0·23	4	—0·00 —0·06	—0·11 —0·16	—0·07 —0·13
7	2	—0·07 —0·16	—0·10 —0·20	—0·09 —0·18	3	—0·08 —0·18	—0·12 —0·23	—0·10 —0·20	2	—0·06 —0·15	—0·06 —0·17	—0·06 —0·16
8	2	—0·03 —0·12	—0·04 —0·12	—0·04 —0·11	3	—0·06 —0·18	—0·10 —0·19	—0·08 —0·19	2	—0·05 —0·08	—0·06 —0·11	—0·06 —0·09
9	2	—0·09 —0·15	—0·11 —0·16	—0·10 —0·16	4	—0·11 —0·21	—0·15 —0·26	—0·13 —0·23	2	—0·09 —0·17	—0·09 —0·17	—0·09 —0·17
10	2	—0·10 —0·16	—0·09 —0·14	—0·10 —0·15	3	—0·07 —0·14	—0·13 —0·18	—0·10 —0·17	2	—0·06 —0·12	—0·07 —0·13	—0·07 —0·13

NOTE :—In the results for each bottle given above, the upper line gives the errors calculated for the bottom half of the graduated scale, and the lower line gives the errors for the whole graduated scale.

2. The thickness of the graduation lines is comparable with the whole space. In fact, in some makes of bottles, the thickness of the graduation lines is quite one-quarter of the whole space between the lines. Hence the difficulty of reading the level, mentioned in the preceding paragraph, is increased.

3. It is difficult sometimes to avoid air bubbles in the mercury when filling the bottle in Method III. Errors would arise from these rising to the surface after a reading of the level is taken. Also, a change of temperature taking place while testing would cause a change in the total volume occupied by these air bubbles, with a consequent change in the level of the mercury in the neck.

4. When testing by the third method, the large amount of mercury filling the bottle causes appreciable errors if the temperature varies while testing, as it is sometimes very liable to do under ordinary conditions of working. For example, the weight of the mercury filling a Babcock milk test bottle is approximately 700 grams. The expansion of that amount of mercury for a rise of temperature of 1°C. is nearly 0·01 c.c., which is equivalent to 0·05 per cent. on the Babcock scale of percentages. This is obviously a very serious error, and is probably the chief difficulty encountered when using this method of calibration.

Under working conditions in the laboratory it was noticed that the reading of the level of the mercury was usually lower after allowing the bottle to stand for a few minutes. Now it is conceivable that the large weight of mercury in the glass bottle might cause an expansion in volume of the flask owing to the elasticity of the glass. It is probable, however, that this is too small to be apparent, and that the fall in the level of the mercury in the neck is practically all due to the lowering of the temperature, for in pouring the mercury into the bottle a small, but appreciable, rise in temperature takes place, as is shown by the following experiment that was carried out:—

Immediately after pouring mercury into a bottle up to approximately the top of the scale, the temperature was carefully observed and a reading of the level taken. These readings were repeated at intervals of five minutes, and the results were as follow:—

Temperature of Mercury in Bottle.		Level of Mercury in Neck
Immediately after filling	22·1°C	7·95 per cent.
After 5 minutes	21·4	7·91 ,, ,,
After 10 minutes	21·1	7·90 ,, ,,
After 15 minutes	21·1	7·90 ,, ,,
Total Change	1·0°C	0·05 per cent.

These results correspond exactly with the change in volume, as calculated above, that would be brought about by a change of 1°C. in temperature in the amount of mercury (700 grams) that fills a bottle of this size. Hence the lowering of the level of the mercury in the neck is practically all due to the fall in temperature that takes place in the mercury when cooling down to the room temperature, after the slight rise that took place when pouring it into the bottle.

4. Owing to the large weight of mercury in the bottle, with the consequent loss of sensitiveness in the balance used, it may be possible to have an error of as much as 0·02 gram when weighing. Now 0·02 gram of mercury occupies a volume of 0·0015 c.c., or nearly 0·01 per cent. on the Babcock scale, which, however, is within the limit of error in reading the scale.

5. Any dust, or dirt of any description, in the bottle fouls the surface of the mercury, thus adding to the difficulty of reading the level correctly.

From the above results and remarks it is seen that the volumetric method given is a fairly reliable method for calibrating Babcock milk test bottles, and is the best one of the three mentioned for ordinary use, when a large number of bottles have to be tested, and when no elaborate precautions can be taken to secure uniformity in the conditions of working, especially as regards temperature.

NOTES ON THE CHEMICAL CONTROL OF CATTLE-DIPPING TANKS.

BY

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Read July 10, 1922.

In these notes an attempt is made to place on record the main results of certain investigations carried out at Cedara during the past year on the chemical behaviour of arsenical dip fluids in cattle tanks, and are really a continuation of the notes recorded in a paper read before this Association in July, 1921, and published in this JOURNAL, vol. xviii, pp. 147-153, December, 1921.

EFFECT OF COAL TAR DISINFECTANTS IN ARSENICAL DIP FLUIDS.

In the above-mentioned paper it was stated by the writer (see page 150 of the above Journal) that the presence of coal tar disinfectants in the two Cedara tanks might be the cause of the abnormal amount of oxidation taking place in them. This statement was based on the conclusions of American investigators, who found that the reducing organisms are more sensitive to such substances than the oxidising organisms. In order to test this statement under ordinary practical conditions, both of the Cedara tanks were cleaned out, and in the new tank a certain proprietary dip which contains a fair proportion of these coal tar derivatives was used, while in the old tank only plain arsenite of soda was used. Furthermore, in order to ensure that there would be a fairly large amount of disinfectant in the new tank, there was added also at the commencement of the investigation some Hycol at the rate of one gallon to every thousand gallons in the tank.

From the commencement of this investigation (May, 1921) up to the end of August, between 100 and 125 head of cattle were dipped at approximately fortnightly intervals in each tank; after that the dipping took place at weekly intervals. The samples from each tank were taken about once a fortnight, immediately after dipping had taken place, to ensure that the contents of the tanks were well stirred. Unfortunately, towards the end of September the old tank developed a bad leak and it had to be abandoned about three months after it had been refilled for the purpose of this investigation.

In addition to the above series of tests, periodical tests were also made of the fluids from several private tanks in this neighbourhood, and a few samples from tanks in other districts in Natal. These private tanks are divided into two groups, the first including those filled with the same proprietary dip as used in

the new tank at Cedara, and the second group including those tanks in which only plain arsenite of soda is used.

The results of all the analyses are given in the following tables:—

II. Tanks on Cedara Farm.

(a) *New Tank* (using an arsenical dip containing coal tar derivatives in addition). This tank was cleaned out and filled with the clean dip on May 17th, 1921.

Date of Sampling.	Amount of Arsenite (Arsenious Oxide.)	Amount of Total Arsenic (calculated as Arsenious Oxide.)	Percentage of Oxidation.
	per cent.	per cent.	per cent.
May 18, 1921. ..	0·154	0·156	1·2
June 19.	0·151	0·173	12·7
July 2.	0·149	0·181	17·9
July 16.	0·147	0·187	21·5
August 2. ..	0·133	0·165	19·2
August 17. ..	0·121	0·154	21·4
August 31. ..	0·124	0·160	22·5
September 16.	0·113	0·160	29·4
October 1. ..	0·120	0·166	27·7
October 13. ..	0·0995	0·1505	33·9
October 20. ..	0·0990	0·1512	34·5
November 8. ..	0·0797	0·1490	46·5

(b) *Old Tank* (using plain arsenite of soda). This tank was cleaned out and refilled on July 18th, 1921.

Date of Sampling.	Amount of Arsenite (Arsenious Oxide.)	Amount of Total Arsenic (calculated as Arsenious Oxide.)	Percentage of Oxidation.
	per cent.	per cent.	per cent.
July 19/21. ..	0·094	0·101	6·9
July 21.	0·107	0·114	6·1
August 4. ..	0·164	0·180	9·3
August 18. ..	0·156	0·172	9·3
August 30. ..	0·154	0·172	10·5
September 16.	0·158	0·178	11·2

Note.—The solid arsenite of soda used for filling this tank had been in stock for several years and had an unusually high percentage of oxidised arsenic (arsenate), hence the high percentage (6·9) of oxidation in the tank immediately after filling.

III. Private Tanks.

(a) Tanks using an arsenical dip containing coal tar derivatives in addition:—

Tank.	Dates of Sampling.	Amt. of Arsenite. (Arsenious Oxide).	Total Arsenic.	Percentage of Oxidation.	Remarks.
	1921.	per cent.	per cent.	per cent.	
A.	July 20	0·073	0·104	29·8	100 head dipped fortnightly.
,,	July 27	0·141	0·158	10·8	Fresh raw dip added.
,,	Sept. 16.	0·094	0·141	33·2	
,,	Nov. 8.	0·090	0·146	38·4	
B.	July 31.	0·089	0·124	27·9	50 head dipped fortnightly.
,,	Sept. 16.	0·057	0·094	39·0	40 head dipped weekly.
,,	Oct. 21.	0·045	0·116	61·5	
,,	Oct. 27.	0·072	0·126	43·1	Fresh raw dip added.
C.	Aug. 16.	0·064	0·076	15·5	100 head dipped weekly.
,,	Nov. 8.	0·059	0·069	13·7	Storm water leaked in.
D.	Sept. 1.	0·047	0·055	14·6	40 head dipped weekly.
,,	Oct. 26.	0·050	0·052	2·0	
E.	Sept. 1.	0·114	0·124	8·0	Tank in use only 1 month.
,,	Oct. 26.	0·100	0·128	21·5	40 head dipped weekly.
F.	Sept. 1.	0·020	0·193	89·6	50 head dipped weekly.
,,	Oct. 26.	0·075	0·225	66·6	Fresh raw dip added.
G.	Sept. 1.	0·093	0·150	38·0	130 head dipped weekly.
H.	Sept. 1.	0·127	0·165	23·0	150 head dipped weekly.
,,	Oct. 26.	0·115	0·162	29·0	
J.	Oct. 26.	0·096	0·113	14·5	Tank in use only 5 weeks. 30 head dipped weekly.
K.	Oct. 31.	0·061	0·063	3·2	140 head dipped weekly.
L.	Sept. 29.	0·053	0·054	2·0	No addition of raw dip to tank for over a year.
M.	Dec. 17.	0·089	0·143	38·0	
N.	Dec. 17.	0·089	0·112	20·8	
	1922.				
O.	May 10.	0·081	0·168	52·0	
P.	June 9.	0·035	0·077	54·8	

(b) Tanks using plain arsenite of soda:—

	1921.	per cent.	per cent.	per cent.	
Q.	July 18.	0·157	0·160	1·9	150 head dipped weekly.
,,	Aug. 31.	0·155	0·158	1·9	
R.	July 24.	0·074	0·075	1·5	250 head dipped weekly.
,,	Sept. 16.	0·110	0·117	6·0	
S.	July 25.	0·140	0·146	4·1	100 head dipped weekly.
,,	Oct. 12.	0·154	0·156	1·3	
T.	Aug. 17.	0·175	0·180	2·8	100 head dipped weekly.
,,	Oct. 31.	0·169	0·175	3·4	
U.	Aug. 17.	0·179	0·182	1·7	150 head dipped weekly.
,,	Oct. 27.	0·205	0·207	0·8	250 head dipped weekly.
V.	Aug. 17.	0·166	0·168	1·2	50 head dipped weekly.
,,	Oct. 27	0·170	0·173	1·4	

It will be noticed in most cases that the amount of oxidation in the tanks containing a disinfectant in addition to the arsenical substance is strikingly larger than in the tanks containing plain arsenite of soda, although in a few instances the amount of oxidation in the former group is unusually low. But these low results can be explained by either of the following reasons:—

1. The tank had only been filled with fresh dip a few weeks previously, as is the case with tanks E and J. Under such circumstances bacterial activity would not have had sufficient time to progress very much.

2. The addition of a large amount of fresh raw dip to make up the strength of the liquid already in the tank, and also a proportionate amount to the fresh water added to make up the volume in the tank. This explains the sudden drop in the percentage of oxidation in tanks A, B and F.

3. It will be noticed that in the case of tanks C, D, K and L, the total amount of arsenic in each tank is consistently low (approximately 0·05 per cent. in each case), and it would appear that under such conditions the activity of the oxidising organisms is approached by that of the reducing organisms. This might be expected, for under these conditions the amount of disinfectant present would also be very small, especially where no addition of fresh dip has been made to a tank for a considerable length of time.

Leaving out the above-mentioned anomalous cases, then, we obtain the following striking results:—

Average percentage of oxidation in the private tanks using the proprietary dip containing coal tar derivatives	41·6 per cent.
Average percentage of oxidation in the private tanks using plain arsenite of soda	2·3 per cent.

This marked difference in the average amount of oxidation in these two groups of tanks can only be explained by the presence of the coal tar derivatives in the proprietary dip. The amount present is not enough to keep the fluid in the tank sterile, and the conjecture made in my last paper concerning the probable explanation of the continuous oxidation during the previous years in the tanks at Cedara seems to be justified, namely, that the reducing organisms are rendered more or less inactive in a partially sterilised medium and that the oxidising organisms are comparatively unaffected.

It was also mentioned in the same paper that recent investigation has shown that the reducing organisms require the presence of a certain amount of fresh urine in the arsenical medium for their growth and well-being. This probably explains the apparently anomalous phenomenon met with in the case of a tank in the Pietermaritzburg district. This tank had only been in use for six or seven months, the arsenical material used being plain

arsenite of soda. When the contents of the tank were tested the amount of arsenite (arsenious oxide) was only 0·062 per cent., but the total arsenic (calculated as arsenious oxide) was 0·300 per cent. The fluid in this particular tank was exceptionally clean and free from organic matter, as only seven head of cattle were put through it every week, so it is likely that it was not a suitable medium to enable the reducing organisms to flourish.

It need hardly be pointed out that the continued general use in dipping tanks of arsenical fluids containing also an appreciable proportion of a coal tar disinfectant is somewhat of a menace to the stock industry, and will always be a source of anxiety to the conscientious farmers and to the officials of the Veterinary Division, who have to see that the regulations governing the dipping of stock are properly carried out. This seemingly rather sweeping statement is justified by the following facts:—

In the first place it is very difficult to keep the tank using such dips up to proper strength, which is essential for the effective control of the ticks. The constant addition of raw dip that is necessary to make up for this continuous oxidation also makes it a very expensive dip to use. This is especially the case when, owing to extensive oxidation and consequent uncertainty as regards the insecticidal value of the fluid, the farmer has to empty his tank oftener than he otherwise would have to.

Secondly, it may be pointed out that farmers and veterinary officials, as a rule, test the strength of a dip in a tank by means of the so-called "field-testers," which only give the amount of unoxidised arsenic in the tank. Now it is usually reckoned that the oxidised arsenic has almost half the insecticidal effect on the tick and also toxicological and excoriating effect on the beast that the unoxidised arsenic has. It therefore happens very often that the "tester" may show a dip to be apparently very much below strength, whereas the total amount of arsenic present may be even more than what is safe for regular dipping. Consequently, the making up of the strength of such a dip, according to the tables accompanying the instructions for the use of the "tester," to the standard strength of unoxidised arsenic, might conceivably have disastrous results. To take the example of the tank in the Pietermaritzburg district previously mentioned, in which the amount of unoxidised arsenic was 0·062 per cent., and of the oxidised arsenic, 0·238 per cent. If this had been made up to standard strength (0·16 per cent.) in unoxidised arsenic as a result of the field test, it would be found (taking the strength of the oxidised as half that of the unoxidised arsenic) that the equivalent amount of arsenic in that tank now would really be about 0·28 per cent., which would certainly be too strong for the five or seven-day dipping of stock, especially calves.

DESCLOIZITE FROM SOUTH-WEST AFRICA.

BY

Percy A. Wagner, Ing.D., B.Sc., F.G.S., M.A.I.M.M.E.

(Communicated by permission of the Honourable the Minister for Mines and Industries.)

Read July 11, 1922.

Superficial deposits of vanadium ore are worked at a number of localities in the Grootfontein district of the South-West Protectorate and form the basis of quite an important industry. The ores occur for the most part in sand or rubble-filled solution cavities and *karrenfelder* in the surface of the Otavi dolomite, more rarely in open solution fissures and in surface breccias, and finally as actual replacements of the dolomite, these being, however, always connected with one or another of the previously mentioned types of deposit.

Some of the occurrences have descloizite as the predominant ore mineral, others mottramite, and yet others (Berg Aukas) apparently vanadinite.* Excellent descriptions of some of the earlier discovered occurrences have been published by H. Schneiderhöhn,† but no comprehensive study of the deposits has as yet been made. It is evident, however, from what is known, that these are all of the nature of residual accumulations formed by the concentration, at favourable *loci*, by descending meteoric waters of small amounts of vanadium disseminated through originally overlying deposits of copper-lead-zinc ore in the Otavi dolomite or the ore-bearing aplite intrusive in that formation.‡ As the vanadium compounds are the last to survive the degradational processes, they are evidently peculiarly resistant to chemical erosion, which is all powerful in a karst region such as that under review.

The object of the present note is to describe some exceptionally handsome specimens of descloizite ore recently sent to the writer by Mr. C. G. C. Clarke, of the South-West Africa Company, Limited. They are from two localities, namely, the farm Olifantsfontein West, situated 12 miles north-west of Grootfontein North, and the farm Abenab, situated 20 miles north of Grootfontein.

At the former, according to the description accompanying the specimens, the deposit takes the form of a well-defined vertical cleft in the dolomite, the walls of which are lined with dark lustrous crystals and crystal aggregates of descloizite forming continuous crusts, several superimposed crusts being in places present.

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* According to a valuable unpublished Memorandum by Mr. G. E. B. Frood, Inspector of Mines, South-West Protectorate.

† cf. "Die Erzlagerstätten des Otaviberglandes, Deutsch-Südwestafrika," *Metall. und Erz.*, XVII, 13, 16, 19, 24, and XVIII, 10 and 11.

‡ Schneiderhöhn, *loc. cit.*, p. 33.

In the material sent to the writer, the crystals range in length from a millimetre and less to 1·7 cm. Actually the largest had a length, measured along the *c* axis, of 1·72 cm, and a breadth measured along the *b* axis of 0·8 cm. They are made up of the unit pyramid and the unit prism, the faces of the latter being generally horizontally furrowed owing to an oscillatory combination of the two forms. More rarely the pyramidal faces are terraced owing to the same cause. The habit of the crystals is sometimes prismatic, the grooving of the prism faces being then especially pronounced. More usually the pyramid and prism faces are about equally developed. Among the smaller individuals, however, crystals of pyramidal habit are fairly common. Single crystals, as a matter of fact, are rare. Even what appear at first sight to be simple forms are generally found to be made up of sub-parallel intergrowths of several crystals, and complex spear-headed and branching groups made up of a number of such crystals sometimes symmetrically arranged about a central dominant stem crystal are very common. The crystal faces give very poor signals and do not lend themselves to accurate measurement, this applying particularly to those of the unit prism. The only angles which could be determined by means of a Fuess reflecting goniometer with even a fair degree of accuracy were as follow:—

$$oo' = (111) : (\bar{1}11) = 89^\circ\ 24'$$
$$oo''' = (111) : (1\bar{1}1) = 52^\circ\ 30'$$

the corresponding values given by Dana* being 89° 6′ and 53° 4′.

The crystals are of a very dark olive green colour and their lustre is brilliant. On fractured surfaces the colour is orange brown, the fracture being uneven. The streak is pale canary-yellow. In the process of grinding down the crystals to prepare thin sections an imperfect cleavage parallel to (100) is brought out.

Under the microscope the crystals are seen to have a well-defined zonal structure, being built up of alternations of thick greenish and thinner brown or yellow layers arranged parallel with the faces. These layers are markedly pleochroic, the greenish showing:—

Z = a = pale yellowish green,
Y = b = pale apple-green,
X = c = very pale yellowish-green,

and the brown or yellow:

Z = a = reddish-brown,
Y = b = greenish yellow,
X = c = pale yellow.

The brownish layers have a much stronger absorption than the greenish. It should be stated that the colours given refer to a fairly thick section. In addition to the brown and greenish zones, a practically colourless zone is generally present in the peripheral portion of the crystals. In one of the sections examined this showed:

Z = pale yellow,
Y = colourless.

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* "A System of Mineralogy," p. 787.

The precise significance of the zoning is not clear. It may be taken for granted, however, that the differently coloured shells also differ in chemical composition, so that instead of dealing with a homogenous mineral we have to do with at least three isomorphous substances.

A chemical analysis by Dr. J. McCrae, of some selected crystals is given under I, in the following table:—

	I.	Ia.	II.	III.
PbO	55·45	0·25	55·93	54·03
ZnO	15·50	0·19	15·94	12·62
CuO	3·80	0·05	1·15	8·13
FeO	—	—	0·70	—
Fe_2O_3	0·30	—	—	—
V_2O_5	22·00	0·12	20·80	22·47
As_2O_5	Nil.	—	0·32	0·28
P_2O_5	—	—	0·27	0·17
SiO_2	Nil.	—	0·18	—
H_2O	2·50	0·14	4·37	2·70
H_2O (110°)	0·05	—	—	—
TOTAL	99·60		99·82	99·74
Sp. Gr.	6·20			

Under Ia are given the molecular proportions corresponding with the analysis. It will be seen that the figures agree fairly closely with the theoretical composition of the mineral, corresponding with the formula 2 PbO. 2(ZnCu) O. V_2O_5. 2 H_2O, according to which lead oxide and zinc plus copper oxide are present in equimolecular proportions, and the ratio of (Pb Zn Cu) O : V_2O_5 : : 4 : 1. The analyses under II and III are adduced for comparison. II is an analysis by W. F. Hillebrand of descloizite from Beaverbrook, Montana, 0·03 per cent. of CaO and 0·06 per cent. of MgO being present in addition to the constituents named. III is an analysis of cuprodescloizite from an unnamed locality quoted from Dana.* As the term cuprodescloizite appears to be reserved for varieties containing a minimum of 6 per cent. of copper oxide, the Olifantsfontein mineral, which, as we have seen, is probably a complex isomorphous mixture of at least three distinct substances, is best described as cupriferous descloizite.

The associated minerals are pellucid bluish-white quartz and calcite. The latter occurs in mammillary crusts up to 1 centimetre in thickness. In these the calcite is evidently paramorphic after aragonite—a phenomenon also noted at other localities in the Otavi Range.† The original aragonite was clearly of later formation than the descloizite, having been deposited on the crystals of that mineral which project into the crusts. The quartz, on the other hand, appears to be of earlier formation than the descloizite.

Abenab.—The Abenab ore is a breccia of strikingly handsome appearance made up of angular fragments of pink surface

* "A System of Mineralogy," p. 789.

† *cf.* Schneiderhöhn, *loc. cit.*, p. 41.

limestone and reddish dolomite encased by crusts of dark green or brown descloizite crystals, the cementing medium being coarsely crystallised white calcite. The latter forms a network of irregular veins up to 2 centimetres, across which are interspersed with vughs lined with crystals of descloizite and colourless calcite. At least four varieties of descloizite are present, namely:—

(1) A blackish green variety occurring in well-formed pyramidal crystals somewhat elongated in the direction of the macrodiagonal. The prism faces are only very poorly developed, and the habit of the crystals is not unlike that of the descloizite from Lake Valley, New Mexico, shown in Fig. 3, p. 788, of Dana's *Mineralogy*. With the aid of a contact goniometer the following forms were found to be present:—

$$p = 111$$
$$m = 110$$
$$v = 021$$
$$(d)? = 012$$

On some crystals the faces of the unit prism are bevelled by those of another prism, probably $l = (130)$. On others the edge $(111) : (\bar{1}11)$ is terraced owing to an oscillatory combination of the two clinodomal faces.

(2) A bottle-green variety occurring in smaller crystals of practically the same habit, the prism being, however, even more poorly developed. One peculiar feature of these crystals is that the clinodomal faces often have a peculiar greenish-yellow coating. Whether or not this is due to the alteration of the descloizite is not clear.

(3) A dull greenish-brown variety in which the habit of the crystals is tabular owing apparently to the abnormal development of the macropinacoid, the other forms present being the unit pyramid and the unit prism.

(4) A lustrous chrome-brown variety occurring mostly in peculiar parallel-growth aggregates, up to 1·5 centimetres in length, imbedded in white calcite. The aggregates are due to the regular conjunction of small crystals of pyramidal habit and are terminated by the unit pyramid. Some of them are doubly terminated.

Chemically the several varieties enumerated appear to differ mainly as regards their copper content. The bright chrome-brown variety is practically free from that element, whereas the very dark variety contains fair quantities of it. No analysis of any particular variety is available, but a sample of the concentrate obtained by jigging the crushed ore, in which all of them are probably represented, showed:—

$PbO = 51{\cdot}81$ per cent.
$ZnO = 18{\cdot}06$,,
$CuO = 1{\cdot}10$,,
$V_2O_5 = 20{\cdot}60$,,
$P_2O_5 = 0{\cdot}08$,,

The writer's thanks are due to Dr. F. E. Wright and Professor Charles Palache for assistance in his investigations.

THE PEPPER TREE (*SCHINUS MOLLE L.*) AS A CAUSE OF HAY FEVER IN SOUTH AFRICA.

BY

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Read July 11, 1922.

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I. INTRODUCTION.

Hay fever is an affliction of the nose, throat and eyes caused in nature by contact with pollens carried in the air. The symptoms are irritation, reddening and swelling of the mucous membranes of these organs, accompanied by a profuse watery discharge. It is thought that these symptoms are induced by poisonous (toxic) proteids, contained in the pollen grains, irritating the membranes concerned. Recent investigations have shown that similar symptoms may be induced by causes other than pollen (Freeman, 1920), but the term hay fever or pollinosis is used where the exciting agent is pollen.

In reviewing some hay-fever work by Dr. Scheppegrell, in America, *The Lancet*, April 22, 1916, states:—"Hay fever is chiefly regarded in this country (England) as a very real, rather distressing but not very serious complaint. . . . . . In certain parts of America it assumes such a severe character that many sufferers have to move into other districts when the spring or autumn fever becomes prevalent, and business may be seriously interfered with solely on this account."

The hay fever prevalent in Bloemfontein is also of this severe type. For several years it has occurred regularly in greater or less severity from about the third week in October intermittently until into January. It is a source of great discomfort and misery to susceptible persons and considerably reduces their efficiency and happiness. The complaint is especially severe during the dry, hot dusty weather prevalent in Bloemfontein at this season.

On examination of the flowers of the pepper tree (*Schinus molle*), to which the epidemics are popularly attributed, they were found to possess the usual characters of flowers pollinated by insects, including an abundance of nectar, viscid stigma and sticky pollen (Potts, 1919). The pollen seemed to be more than ordinarily adhesive, as the anthers were often stuck together by it, and when pollen was dropped on to smooth paper or glass it was impossible to blow it off with the mouth. Hence it was concluded that pepper tree pollen was not wind-borne, and could, therefore, not be the cause of the epidemics. During the next hay fever season the investigation could not be continued because of the influenza epidemic, but in 1919 steps were taken to ascertain the varieties of pollen floating in the air.

As the conclusion is arrived at that the epidemics investigated are to a very great extent dependent on the climate, an account will first be given of the climate of Bloemfontein.

II. Climate of Bloemfontein.

The following statistics give a general idea of the climatological conditions prevailing, but as figures alone are apt to be lifeless or even misleading they are supplemented by a descriptive account and some impressions of the weather. The statistics should be compared with those of other centres whose climate is known. I felt the need of weather records in studying Dr. Scheppegrell's valuable reports on hay fever in America, and it is almost impossible to procure from another country statistics sufficiently detailed to be of value. A knowledge of the climate is also necessary to understand the nature and periodicity of the vegetation. Additional information regarding the Bloemfontein climate will be found later in the report, especially in the sections dealing with the exposure of pollen plates, the drying of the pollen, and the occurrence of pepper trees in other towns of the Union. Temperatures are in degrees Fahrenheit and rainfall in inches. The latitude of Bloemfontein is 29° 07′ S.; distance from the sea (nearest point) about 290 miles; altitude 4,568 feet; and average barometric pressure, 25·6 inches.

TABLE I—SUMMARY PREPARED FROM METEOROLOGICAL OBSERVATIONS TAKEN AT BLOEMFONTEIN DURING THE THREE YEARS 1919, 1920, 1921.

Month.	Hygrometer.		Shade Temperatures.				Average Total Rainfall in inches.	Average Rainfall (omitting falls less than 0·3 inch and calling as 2 inches amounts over this).
	Dry Bulb.	Wet Bulb.	Average Maximum Temperature F.	Average Minimum Temperature F.	Absolute Maximum Temperature	Absolute Minimum Temperature		
January	72·5	61·4	88·3°	59·9°	97·0°	49·5°	2·04	1·39
February	69·0	61·2	82·7	59·5	95·8	46·4	5·10	3·74
March	64·6	58·9	78·3	55·1	91·4	37·7	4·12	2·88
April	59·5	54·0	74·5	48·9	84·7	34·9	1·18	0·68
May	48·7	44·4	65·9	39·5	76·9	23·0	1·22	0·90
June	41·2	36·7	61·97	32·3	73·9	17·8	0·02	—
July	40·9	36·1	62·1	31·1	71·2	16·1	0·13	—
August	47·3	40·3	—	36·8	80·0	21·9	0·25	0·17
September	55·9	46·7	72·2	42·2	87·7	26·0	0·53	0·26
October	65·1	53·3	80·5	50·2	92·9	34·5	1·51	1·05
November	67·5	57·2	81·6	54·3	94·0	38·6	1·43	0·63
December	71·6	59·2	85·1	58·1	96·0	41·0	1·35	0·68
Total							18·88	12·38

Hours of Sunshine:

The mean number of hours of bright sunshine experienced daily at Kimberley is 9·4, and at Johannesburg 8·7, as compared with 3·8 for London and 6·9 for New York (Cox, 1922). There are no records available for Bloemfontein, but the figures for it would probably lie between those for Johannesburg and Kimberley.

Wind:

The prevailing wind at Bloemfontein is westerly; it is dry and frequently strong and gusty. The north-easterly and easterly winds carry moisture to this part of the country, but unfortunately they have dropped much of their water-content in rising to the High Veld; they are rarely stronger than a gentle breeze and always pleasantly moist. The south wind is also only rarely strong; it always causes a considerable fall in temperature and, in winter, is bitterly cold.

The official daily weather observations for Bloemfontein, which it should be remembered are taken at 8.30 a.m., are really very misleading as regards the wind. Many of them are given in connection with the exposure of pollen plates at Bloemfontein. They leave the impression that Bloemfontein is fanned by gentle breezes even in the spring and early summer. In reality, at this season a dry westerly wind frequently springs up towards the middle of the forenoon and blows in gusts until late in the afternoon. It is almost invariably dusty, and, though not of daily occurrence, is a distinguishing and unpleasant feature of the Bloemfontein climate, especially from July until the summer rains begin, which may be as late as February. During the hot weather this wind is correspondingly hot, dry and parching. Its influence on the climate and vegetation is very marked, and it also plays a rôle in connection with hay fever.

Rainfall and Evaporation:

The average annual rainfall at Bloemfontein since 1880 is 21·73 inches (Cox, 1922). Its effect on the climate and vegetation is, however, reduced by the unequal distribution throughout the year, the manner in which it falls, the bare and frequently baked surface of the ground, and the intense evaporation.

From an inspection of Table II it will be evident that the bulk of it falls at one season—in the late summer, especially in February and March. The heavy rains usually fall in the form of violent thunderstorms, and so rapidly that much of the water cannot be absorbed by the ground. A large proportion therefore runs off as surface water and, incidentally, causes sluiting. Another large proportion is lost by falling in showers

too small to be of any practical value. The number of these very light showers will be evident from an inspection of Table III, which shows the daily rainfall for three years. To select two examples: in December, 1919, though rain was recorded on 8 days, the total for the month was only 0·50 inches, being an average of 0·06 inches; and for November, 1921, a more extreme case, rain on 17 days totalled only 1·36 inches, or an average of 0.07 inches. A study of this table also reveals the interesting fact that the amount of rain most frequently recorded for Bloemfontein is "0.00" inches, which, I understand, is the official method of indicating a shower of less than one-hundredth of an inch. These showers temporarily soften and cool the air, but are rarely of any real benefit to vegetation.

TABLE II

BLOEMFONTEIN: Monthly Rainfall for three years.

Month.	1919 Total Rainfall (in inches).	1919 Rainfall (omitting falls less than 0·3in. and taking as 2 in. amounts over this).	1920 Total Rainfall (in inches).	1920 Rainfall (omitting falls less than 0·3in. and taking as 2 in. amounts over this).	1921 Total Rainfall (in inches).	1921 Rainfall (omitting falls less than 0·3in. and taking as 2 in. amounts over this).
January ..	2·87	2·05	2·17	1·76	1·08	0·36
February ..	0·48	—	8·20	5·13	6·62	6·08
March ..	2·60	1·97	5·99	3·43	3·78	3·24
April ..	1·28	0·73	0·21	—	2·05	1·30
May ..	0·37	0·37	0·39	—	2·91	2·33
June ..	0·00	—	0·07	—	—	—
July ..	0·39	—	0·00	—	—	—
August ..	0·11	—	0·65	0·50	—	—
September	0·44	—	0·56	0·41	0·60	0·38
October ..	0·65	—	3·38	3·15	0·49	—
November..	1·95	0·82	0·98	0·65	1·36	0·43
December	0·50	—	0·60	—	2·96	2·05
TOTALS ..	11·64	5·94	23·20	15·03	21·85	16·17

In Table II an attempt has been made to allow for this wastage by omitting showers of less than 0·3 inch and taking as 2 inches amounts greater than this. The result for the three years 1919-1921 is that

a total rainfall of 12 inches in 1919 becomes 6 inches

a total rainfall of 23 inches in 1920 becomes 15 inches

a total rainfall of 22 inches in 1921 becomes 16 inches

taking the nearest whole figures. The method is, of course, purely arbitrary and is open to criticism. It is really only a first attempt to eliminate the relatively valueless part of the rain. Small showers within a few days after a growing rain no doubt do very appreciable good, but it would be difficult to agree on the limits of amount and period; on the other hand, it is very doubtful whether a really heavy thunderstorm, of say four inches within perhaps as many hours, does as much good as a fall of two inches of average steadiness. Much, too, depends on the nature of the soil and on the amount of vegetable covering present. As the daily rainfalls are given, the estimate can be readjusted at discretion.

Evidence is adduced that in Bloemfontein these light showers play a rôle in the hay fever epidemics.

The evaporation is very high, as is indicated by the following figures giving the annual evaporation from free water surfaces:

Bloemfontein (Mazelspoort) 82·5 inches.

Johannesburg (Cox, 1922) 74·67 inches.

The figure for Johannesburg is from Meteorological Office data. That for Bloemfontein is calculated from records taken by the City Engineer's Department near the Municipal Dam some 16 miles east of the town, and is the average of the three years 1919-1921.

The high evaporation figure is to be attributed to the dry rarefied air, high temperature and, especially no doubt, to the prevailing strong, dry, westerly wind.

The result is that, although Bloemfontein has a moderate rainfall, the outstanding feature of the climate is its dryness. This is indicated in the low relative humidity of the air, shown graphically in the chart on p. 190. Additional evidence is to be found in the general jubilation occasioned by a good rain, and the columns of detail to which it gives rise in the daily press; as also in the local practice of describing as "Promising" weather which is cloudy and overcast.

It may not be generally realised that the average rainfall of Bloemfontein (21·73 inches) is almost identical with that of some parts of the county of Norfolk, England: e.g., Cromer, latitude 52° 56′ N. has an average of 21·77 inches. Yet how different is the climate! But the latitude of Cromer is higher, there is no doubt more cloud, and it is on the sea and, virtually, at sea-level (196 feet). The temperature will, therefore, be less, and the air (and winds) more moist. Hence the evaporation will be less. The two centres nearest Cromer, for which evaporation figures are available, are Worstead and Ormesby; and at these stations the average evaporation for 1919 and 1920 was respectively 16·3 and 20·8 inches.

Table III

Bloemfontein: Daily Rainfall (in inches) for three years.

1919.

Day.	Jan.	Feb.	March	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	0·67		0·23	0·19	0·37						0·31	
2			0·00								0·49	0·02
3	0·32		0·01									
4				0·09					0·13			
5			1·03						0·03			0·00
6			0·00									
7	0·00			0·04			0·25	0·01	0·02		0·31	
8			0·06	0·33		0·00	0·06	0·08		0·22		
9				0·00				0·02				
10												
11			0·00						0·26			
12		0·00							0·00			
13	0·05											
14		0·05			0·00							
15						0·00					0·10	
16	0·19		0·00				0·08			0·26	0·25	
17	0·01	0·00	0·24				0·00			0·07		
18	0·50		0·22									
19		0·27	0·52								0·08	
20	0·00	0·00		0·11							0·01	
21	0·88			0·40								
22	0·06	0·00										0·00
23												
24		0·05									0·07	
25		0·11										
26				0·00								0·00
27	0·08			0·08								0·00
28				0·01				0·00			0·33	0·28
29								0·00		0·07		0·20
30			0·00	0·03								
31	0·11		0·11							0·03		0·00
Total for month	2·87	0·48	2·60	1·28	0·37	0·00	0·39	0·11	0·44	0·65	1·95	0·50

TABLE III (*continued*).

BLOEMFONTEIN: Daily Rainfall (in inches) for three years.

1920.

Day.	Jan.	Feb.	March	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1		0·43	0·71		0·00					1·58	0·00	
2			2·86	0·00					0·00			
3			0·11								0·00	
4		0·00	0·55						0·02			0·00
5	0·00	0·86		0·00		0·00			0·41	0·01		
6	0·18									0·06		
7												
8				0·08	0·00							
9		0·04		0·04							0·11	
10		0·06										0·00
11				0·07			0·00					
12			0·00			0·06			0·04			
13	0·00	0·17	0·02		0·18						0·01	
14	0·00	0·41			0·21							
15		0·24	0·41		0·00	0·01						0·26
16	0·00		0·01									
17								0·00			0·15	0·00
18		0·03										0·00
19												
20		0·00	0·90					0·15				
21		0·78						0·50		0·10	0·00	
22		0·11	0·30	0·00				0·00			0·05	0·00
23	0·00		0·12	0·02				0·00		0·47	0·00	0·13
24	0·00		0·00							1·10		0·00
25	0·00	0·10									0·65	
26		0·25			0·00						0·01	
27		0·65								0·00		
28		4·03								0·06		0·00
29	0·79	0·04										
30	0·97								0·09			0·12
31	0·23											0·09
Total for month	2·17	8·20	5·99	0·21	0·39	0·07	0·00	0·65	0·56	3·38	0·98	0·60

TABLE III (*continued*).

BLOEMFONTEIN: Daily Rainfall (in inches) for three years.

1921.

Day.	Jan.	Feb.	March	April	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1		0·00			0·29					0·00		
2			0·07							0·10	0·05	
3	0·36	1·21			0·21					0·05	0·07	
4	0·06		0·13		0·08						0·01	0·17
5				0·26								0·02
6			0·04		0·45						0·00	0·10
7	0·16		0·00		1·88					0·21	0·15	0·15
8	0·19		0·49	0·00					0·38	0·00	0·23	0·71
9	0·00			0·71				snowy	0·00			0·83
10		0·64										
11	0·03	0·00										
12		0·00									0·23	
13		0·09	0·00	0·09								
14		0·28		0·03	0·00							
15		0·17										
16		0·68	0·00									
17		0·50	0·03									0·00
18		1·62										
19	0·00	0·55									0·04	
20	0·00		0·00								0·00	
21		0·00		0·02							0·01	0·27
22		0·88	0·11	0·59					0·22		0·43	
23											0·01	
24	0·22		0·03								0·03	0·51
25			0·10								0·00	
26	0·06		0·69							0·08	0·04	
27			0·03							0·05	0·01	
28			0·57								0·05	0·20
29				0·09						0·00		
30			0·70	0·26								
31			0·79									
Total for month	1·08	6·62	3·78	2·05	2·91				0·60	0·49	1·36	2·96

III. Determination of Pollens in the Air of Bloemfontein during the Epidemic Hay Fever Season.

(a) Method and Experiments in October and November, 1919.

To determine the varieties of pollen in the air of the town glass plates smeared with vaseline were suspended in the open air and afterwards examined under the microscope. Considerable difficulty was encountered in finding a suitable adhesive, glycerine, linseed oil (boiled and unboiled), gelatine, agar, and several others being tried, but the only substance that remained on the plate and retained its stickiness was vaseline. Ordinary photographic quarter-plates ($3\frac{1}{4}$ by $4\frac{1}{4}$ inches) were used: these were smeared on one side and hung vertically in a position exposed to the wind at a height usually of about five feet. The length of exposure allowed varied from 14 to 84 hours, depending on the exigencies of College work, and is given in the tables, where the date stated is that on which the period of exposure ended. The plates were collected about 10 a.m. as a rule.

The comments regarding the weather should be consulted in conjunction with the official meteorological observations, given in separate tables, for the same date. The comments direct attention only to features which are regarded as of importance in connection with the occurrence of pollen in the air, and are not given in the official weather records. The weather conditions reported are to be understood as having usually obtained during only a part of the period of exposure. Unless stated to the contrary the wind was westerly, and of the type already described.

In the microscopic examination of the large plates for pollen, three areas chosen at random were covered and part of each was searched systematically with the aid of a mechanical stage. Very great difficulty was experienced in this work owing to the large amount of dust which had adhered to the vaseline. After a severe dust storm the particles of dust were so thick as to make it probable that some of the pollen would escape detection, but even when the dust was only one layer in thickness its presence greatly complicated the examination of the plates and prolonged the time required. Eventually means were devised for separating the dust from the pollens. This was done by scraping the vaseline from the surface of the plate, dissolving it in petrol and centrifuging, whereby the heavy mineral matter was thrown to the bottom. Some of the clear petrol solution was then transferred to a slide and concentrated by evaporation; and after this had been repeated several times, portions having been taken from various levels in the liquid, the deposit was examined. In this way the dust was got rid of and the pollen concentrated. The method proved very useful where there was a great deal of dust on the plates, but has the disadvantage of not giving strictly quantitative results, such as can be obtained by direct examination. A comparison, however, of the results of direct examination and of examination after centrifuging, made in a number of plates, showed that there was a rough parallelism both as regards varieties of pollen and their relative amounts.

TABLE IV

EXPOSURE OF POLLEN PLATES AT BLOEMFONTEIN, OCTOBER AND NOVEMBER, 1919.

Place of Exposure.	Date.	Duration of Exposure in Hours.	Dust.	Pepper Tree Pollen.	Other Pollens.
Grey University College	Oct. 15	24	Very plentiful	—	—
Oranje School	Oct. 16	28	Fairly plentiful	—	11
Milner Road	Oct. 16	24	—	—	—
Milner Road	Oct. 21	15	Plentiful	—	—
Milner Road	Oct. 24	17	A little	—	—
Ramblers Club	Oct. 28	74	Plentiful	Very plentiful 205	A few. 5
Government Buildings	Oct. 28	74	Fairly plentiful	Fairly plentiful	—
Park Road	Oct. 28	74	Fairly plentiful	Plentiful	—
Milner Road	Oct. 28	74	Fairly plentiful	—	—
Ramblers Club	Nov. 1	14	—	Plentiful 11.	—
Government Buildings	Nov. 1	14	—	—	—
Park Road	Nov. 1	14	Fair	Plentiful	A little.
Bloemfontein Club	Nov. 1	26	Plentiful	—	—
Bloemfontein Club	Nov. 5	48	Plentiful	—	Several.
Park Road	Nov. 5	48	A little	—	—
Ramblers Club	Nov. 7	24	Plentiful	—	—
Bloemfontein Club	Nov. 7	24	Plentiful	—	—
Park Road	Nov. 7	24	Plentiful	—	—
Ramblers Club	Nov. 8	24	Plentiful	—	—
Ramblers Club	Nov. 10	48	—	—	—
Bloemfontein Club	Nov. 10	48	Very plentiful	A little. 7	A few. 3.
Park Road	Nov. 10	48	—	—	10
Ramblers Club	Nov. 11	24	Very little	—	—
Bloemfontein Club	Nov. 11	24	Fair	Fairly plentiful	2
Park Road	Nov. 11	24	A little	—	—
Ramblers Club	Nov. 13	48	Plentiful	A little. 6	—
Bloemfontein Club	Nov. 13	48	Plentiful	Plentiful 18	A few. 9
Park Road	Nov. 13	48	Very plentiful	Plentiful 18	—
Ramblers Club	Nov. 14	24	Plentiful	Fairly plentiful 11.	—
Ramblers Club	Nov. 14	84	Plentiful	Plentiful 22	—
Ramblers Club	Nov. 14	24	Plentiful	Plentiful 15	—
Bloemfontein Club	Nov. 15	48	A little	A little 4	—
Park Road	Nov. 15	48	Plentiful	Plentiful 25	—
Ramblers Club	Nov. 17	48	Very plentiful	Fairly plentiful 8.	—
Bloemfontein Club	Nov. 17	48	Very plentiful	A little	—
Park Road	Nov 17	48	Very plentiful	A little	—
Ramblers Club	Nov. 18	24	Fairly plentiful	—	—
Bloemfontein Club	Nov. 18	24	—	—	9
Park Road	Nov. 18	24	Very little	—	—
Ramblers Club	Nov. 20	48	Very plentiful	Very plentiful 32.	—
Bloemfontein Club	Nov. 20	48	Very plentiful	Fairly plentiful	—
Park Road	Nov. 20	48	Plentiful	—	—
Ramblers Grounds	Nov. 21	64	Plentiful	Plentiful	Plentiful.
Ramblers Grounds	Nov. 21	64	Fairly plentiful	Plentiful	—
Ramblers Club	Nov 29	48	Fairly plentiful	A little 7	3
Bloemfontein Club	Nov. 29	48		—	—
Park Road	Nov. 29	48		—	—

Where only a single grain of a particular kind of pollen was observed, this was not usually recorded. With this exception the number of grains of pollen counted by direct examination is recorded. The verbal estimate regarding the amount of pollen records the impression left by an examination of the centrifugal material. No stain was found whose use materially facilitated the examination of the plates.

TABLE IV (*continued*).

EXPOSURE OF POLLEN PLATES AT BLOEMFONTEIN, OCTOBER AND NOVEMBER, 1919.

Comments (on weather during exposure of slide; on pollens found, etc.)
Windy and dusty.
Very windy and dusty. Eight of the grains were Pine pollen. the remaining three were large oval grains with pointed ends, kind unknown.
Windy.
Very windy and dusty.
Somewhat windy.
Hot, very windy and dusty; 205 grains of pepper tree pollen, mostly in groups, were counted on area of 16 m.m. x 8 m.m. The five other Pollens were all pines. The plate was only some 35 feet away from the nearest edge of the crown of a male pepper tree; and was about the same height as the top of the crown.
Hot, windy and dusty.
Hot, very windy and dusty.
Hot, very windy and dusty.
Fairly calm.
Fairly calm.
Fairly calm, the other Pollens were grass, grains circular.
Fairly calm
Somewhat windy and dusty; the other Pollens were Artemisia.
Somewhat windy and dusty.
Very windy and dusty.
Very windy and dusty.
Very windy and dusty.
Calm. Rain fell on the 7th.
Cold South wind.
Cold South wind. Two of the other Pollens were Chilianthus.
Cold South wind. Small circular grains of grass pollen.
Calm.
Calm. Single grains of two kinds.
Calm.
A violent dust storm on the 12th; air very dry.
A violent dust storm on the 12th; air very dry. The other Pollens were Chilianthus and an unknown kind of pentagonal outline.
A violent dust storm on the 12th; air very dry. The grains of pepper tree pollen were in groups of 2 and 3.
Air dry; hot, windy and dusty.
Air dry; hot windy and dusty.
Air dry; hot, windy and dusty.
Strongly westerly wind during day; dry and hot.
Strongly westerly wind during day; dry and hot.
Very windy during part of time.
Very windy during part of time,
Very windy during part of time.
Mostly calm.
Mostly calm. The other Pollens were small circular grains of grass (?) pollen
Mostly calm.
Hot, windy and dusty.
Hot, windy and dusty.
Hot, windy and dusty.
This plate was hung in a Eucalyptus tree some 150 paces from the nearest male pepper tree. The other pollen was all Eucalyptus and this was the only occasion on which this kind of pollen was found on the plates.
Hot and dry; of the 3 pollens, 2 were the grass recorded on the 18th, and one Artemisia.

The following particulars should be noted regarding the sites at which the pollen plates were exposed:

Grey University College: This is to the west of and beyond the town. There were no pepper trees near the plates and none at all to the west. (It will be remembered that during the season when epidemic hay fever occurs the prevailing wind is from the west.)

Oranje-Skool and *Milner Road* are on the extreme western side of the town; and there were few or no pepper trees to the west of the plates.

Ramblers' Club.—This is in the central part of the town, and pepper trees are plentiful in the neighbourhood. Unless stated to the contrary, the plates were hung on the balcony about 28 feet above the ground, and some 40 paces from the nearest pepper tree. In a few specified cases the plates were hung in the grounds attached to the Club.

Government Buildings.—Pepper trees are plentiful in the neighbourhood and occur on all sides of the site, but there were none within some 60 paces of the plates.

Park Road.—The site is also on the extreme western side of the town, but there was a row of pepper trees some 18 paces to the west of the plates. These were the only pepper trees in the neighbourhood.

Bloemfontein Club.—This is in the central region of the town, pepper trees occur on all sides, but at a considerable distance. The plates were hung on the balcony.

(The meteorological conditions in Bloemfontein during the exposure of pollen plates are given in Tables V, VI).

TABLE V

METEOROLOGICAL OBSERVATIONS: BLOEMFONTEIN, OCTOBER, 1919.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Max. Temp.	Direction of Wind.	Force of Wind 0—12	Rainfall (inches).
October 15	66·7°F.	56·0°F.	86·1°F.	N	3	
16	73·6	59·9	86·5	NNW	3	0·26
17	67·5	59·8	76·8	NNW	3	0·07
18	65·5	54·9	73·0	W	2	
19	53·2	44·8	66·2	S	4	
20	55·8	46·2	73·0	SE	2	
21	60·6	52·0	79·5	N	4	
22	68·6	54·9	88·3	NW	4	
23	71·1	50·8	87·9	NNW	1	
24	72·0	50·0	90·3	E	1	
25	72·0	50·3	85·7	NW	2	
26	69·9	58·3	81·2	NE	2	
27	70·7	58·5	90·4	NW	2	
28	72·6	59·5	89·6	N	2	
29	69·1	58·3	85·5	N	3	0·07
30	66·5	58·0	79·8	WSW	1	
31	70·9	59·7	81·1	NE	1	0·03
Average for 17 days	67·4	54·8	82·4			

During the hay fever epidemic of 1919 at Bloemfontein, some 47 pollen plates were exposed on 30 days between October 15 and November 29. Particulars are given in Table IV, and the results may be summarised as follows:—

Number of pollen plates exposed	47
Number of plates on which no pollen was found	20
,, ,, pollen of some kind was found ...	27
,, ,, pepper tree pollen was found ...	23
,, ,, pollen other than that of the pepper tree was found	11

The outstanding features shown in the table are the frequency and amount of both dust and pepper tree pollen and the scarcity of other pollens both as regards varieties and amount.

TABLE VI

METEOROLOGICAL OBSERVATIONS: BLOEMFONTEIN, NOVEMBER, 1919.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Max. Temp.	Direction of Wind.	Force of Wind. 0—12	Rainfall (inches)
November 1	72·5°F.	61·1°F.	80·5°F.	NNW	2	0·31
2	58·9	58·0	64·2	N	1	0·49
3	65·0	58·0	80·0	E	1	
4	55·1	44·8	72·6	SE	3	
5	64·1	50·8	78·4	NNE	2	
6	58·0	45·0	67·9	NNE	1	
7	60·8	55·0	69·0	NE	3	0·31
8	54·7	50·9	61·9	S	3	
9	53·6	44·9	67·4	SSE	4	
10	60·5	51·1	73·1	NNW	3	
11	66·9	56·0	80·7	NW	3—4	
12	67·9	54·8	84·2	WNW	4	
13	73·2	54·0	86·1	N	2	
14	75·0	57·5	88·1	SSE	2	
15	74·1	58·2	90·6	N	3	0·10
16	62·3	59·0	79·1	WNW	2	0·25
17	67·5	57·2	81·7	N	1	
18	68·8	59·0	88·2	SSE	1	
19	74·8	61·1	92·9	NW	3—4	0·08
20	63·0	59·7	74·1	ESE	1	0·01
21	58·0	51·9	76·2	E	1	
22	64·0	55·3	79·9	NNE	2—3	
23	66·4	58·3	78·2	N	2—3	
24	71·7	62·9	86·1	NNW	1	0·07
25	69·0	62·1	86·1	N	2	
26	73·2	63·0	88·5	N	2	
27	70·4	61·7	89·8	N	2—3	
28	72·8	63·0	78·8	WNW	3—4	0·33
29	65·1	51·7	82·3	NNW	1	
30	71·8	54·1	87·2	SE	2	
Average ..	66·0	56·0	79·8			

It will be seen that dust was almost invariably present on the plates and usually in large amounts. Its presence in the air no doubt aggravates the effect of pollen in causing hay-fever by irritating and making more susceptible the mucous membranes of the nose, throat and eyes: moreover its influence is probably cumulative and increases as the dusty season is prolonged.

Pepper Tree Pollen:

Of 27 plates on which pollen was found, no less than 23 had pepper tree pollen on them; and with one exception, that of a grass whose pollen occurred on three occasions, no pollen other than that of the pepper tree was found more than twice, single grains omitted.

Pepper tree pollen was, therefore, to an overwhelming degree the chief pollen in the air of the town during the period and none of the other pollens were found sufficiently frequently or in sufficient numbers to suggest that they play an important part in causing the epidemics.

In Dr. Scheppegrell's investigations (1917) he adopted the number of pollen grains falling on a square centimetre in twenty-four hours as the unit for expressing the density of a particular pollen in the air. He found that with most pollens 25 grains per square centimetre is sufficient to cause hay-fever in most subjects, whilst 100 per square centimetre causes atttacks of considerable severity.

Table VII gives particulars of the density of pepper tree pollen found at Bloemfontein on eight occasions in 1919. The figure given in the last column was arrived at by working across the microscopic field a varying number of times, and reducing to the area and time adopted in the unit.

TABLE VII

DENSITY OF PEPPER TREE POLLEN: BLOEMFONTEIN, 1919.

Date of Exposure of Pollen Plate.	Period of Hours.	Number of Pollen Grains Counted.	Site at which exposed.	Density of Pepper Tree pollen expressed in numbers of grains falling on a square centimetre in 24 hours.
Oct. 26—28 ..	74	205	Ramblers Club	55
Oct. 31—Nov. 1	14	11	,, ,,	206
Nov. 11—13 ..	48	6	,, ,,	55
Nov. 11—13 ..	48	18	Park Road	84
Nov. 11—14 ..	84	22	Ramblers Club	60
Nov. 13—14 ..	24	11	,, ,,	103
Nov. 13—15 ..	48	25	Park Road	117
Nov. 18—20 ..	48	32	Ramblers Club	150

According to Dr. Scheppegrell's experience these densities should be sufficient to cause hay fever of considerable severity, and, in point of fact, severe cases of hay-fever were prevalent in the town at this time. As little or no other pollen was being found on the plates it is to be presumed that the attacks were due to pepper tree pollen.

It is worthy of note that the occasion on which the largest number of grains of pepper tree pollen was counted on a plate, viz., 205, on October 28, works out, when expressed in Dr. Scheppegrell's unit, to the lowest density shown in the table. This is because of the longer period of exposure, viz. 74 hours. It should be emphasised, however, that the densities are to be regarded as purely local and not as being general for the whole town. Thus, whilst a plate exposed at the Ramblers' Club on November 1 gave a density of pepper tree pollen represented by 206 (a very high figure), no pollen whatever was found on a plate exposed for exactly the same period at Government Buildings, less than half a mile distant. Also on November 20, whilst no pollen was found on a plate exposed at Park Road, another exposed at the Ramblers' Club for exactly the same period had pepper tree pollen present in amount equivalent to the very high density of 150.

The irregular occurrence of pepper tree pollen on the plates presents some curious anomalies. One would hardly expect to find pollen in the air in wet weather, nor in the absence of wind, but an examination of the tables will show that pepper tree pollen was frequently not found on the pollen plates in weather that seems suitable for the dispersal of pollen. Subsequent experience showed that the weather has a determining influence not only on the dispersal of the pollen of the pepper tree, but also on the opening of its flowers and the drying of the pollen: two essential preliminaries for dispersal. In other cases the direction and strength of the wind, and position of the pepper trees in the vicinity in relation to the place of exposure of the pollen plates, offer a sufficient explanation—see notes regarding sites of exposure.

The circumstance that there were no pepper trees to the west of and near the place of exposure of the first five plates shown in Table IV is, in the light of subsequent experience, a sufficient reason for the absence of pepper tree pollen from these plates.

Other Pollens:

Regarding pollens other than that of the pepper tree:

1. Pine pollen was found twice, both dates being in October. As a cause of the epidemic it need not be further considered, as its principal flowering season in Bloemfontein is the last fortnight in September; and, except for isolated trees, it has ceased to provide pollen before the hay fever epidemic commences. The species is *Pinus halepensis*.

2. *Chilianthus arborens* Benth.—This pollen was also found only twice. The plant is locally known as the Vaal Bos and is

the dominant shrub on the hills to the north of the town. In cutaneous tests on three typical epidemic patients its pollen produced no reaction, whereas a control test made with pepper tree pollen gave a strong reaction in all three patients.

3. *Artemisia afra* Jacq.—This is the plant locally known as the Wormwood or Wilde Als. Except for single grains, which occurred on four plates, this pollen was found only once, but its presence is of great importance because of its extreme virulence. This was demonstrated by Dr. Scheppegrell (1917), who, in tests covering a large variety of American hay-fever pollens, found that of Artemisia considerably the most virulent. Artemisia is one of the commonest hay-fever plants in the dry inland regions of the United States, where several species are common, one, the Sagebrush, forming the principal vegetation over thousands of acres. Near Bloemfontein Artemisia is found to-day in only small quantities, single plants and small patches occurring on the hills to the north and north-east of the town. The amount of the plant in the vicinity of the town is insufficient to suggest that it could be a general cause of hay-fever, and the small amount of its pollen found on the plates is probably in fair proportion to its importance in this connection.

4. The only other pollen found more than once on the plates was an undetermined grass which was present on three occasions.

5. It will be noticed that, except for pepper tree pollen, the total amount of pollen in the air of the town is small and the number of kinds few. This is the case at all the centres at which plates were exposed, but most noticeably so at the Ramblers' Club. During the epidemic seasons of 1919, 1920 and 1921, plates were exposed here over a total period of 57 days and yet, except for single grains, pollen other than that of the pepper tree was found on only 2 plates, on one of which the only pollen, in addition to that of the pepper tree, was that of a cultivated pine. Yet at this site the plates were hung some 28 feet above the ground on a balcony with free exposure to the wind, where they might be expected to catch any pollens floating in the air.

The great variation in the pollen found on plates exposed at the same time and for the same period in different parts of the town is one of the noteworthy features shown in the Tables. The distribution of the pollens would indicate that they are local in origin, since, if pollen had been carried for any considerable distance by the wind, it would have been more widely distributed. From the result shown in the Tables it would appear that no pollen, not even that of the pepper tree, was distributed through the air of the whole town.

(b) Experiments in November and December, 1920.

At Bloemfontein during the epidemic season of 1920, plates were exposed on 16 days between November 25 and December 23. Particulars are given in Table VIII. The total number of plates exposed was 22, and the period of exposure varied from 24 to 72 hours. Dust was found on all the plates, often in large quantities, and pepper tree pollen, in varying amounts, on 20 of

them. No other pollen, omitting single grains, was found on any of the plates. The following particulars should be noted regarding the places at which the plates were exposed:

TABLE VIII—EXPOSURE OF POLLEN PLATES: BLOEMFONTEIN, NOVEMBER AND DECEMBER, 1920.

Place of Exposure.	Date.	Duration of Exposure (hours).	Dust.	Pepper Tree Pollen.	Other Pollen.	Comments on Weather.
Second St.	Nov. 26	24	Very plentiful ..	Fairly plentiful	—	Dry, hot, windy. *
Ramblers Club ..	Nov. 26	24	,, ,,	A little	—	,, ,,
Second St.	Nov. 29	72	A little	Very plentiful ..	—	Shower, otherwise dry, hot, windy.
Ramblers Club ..	Nov. 29	72	Fairly plentiful ..	,, ,,		,, ,, ,,
Second St.	Dec. 1	48	Very plentiful ..	A little	—	Dry, hot, windy.
Ramblers Club ..	Dec. 1	48	,, ,,	Fairly plentiful ..	—	,, ,, ,,
Second St.	Dec. 2	24	A little	A little	—	,, ,, ,,
Ramblers Club ..	Dec. 2	24	,, ,, ...	,, ,,	—	,, ,, ,,
Second St.	Dec. 3	24	,, ,,	,, ,,	—	Dry, hot, fairly calm.
Ramblers Club ..	Dec. 3	24	Fair	,, ,,	—	,, ,, ,,
Second St.	Dec. 4	24	Very plentiful ..	Fairly plentiful ..	—	Dry, hot, very wind .
Ramblers Club ..	Dec. 4	24	A little	,, ,,	—	,, ,, ,,
Second St.	Dec. 6	48	,, ,,	,, ,,	—	,, ,, ,,
Ramblers Club ..	Dec. 6	48	,, ,,	,, ,,	—	
Ramblers Club ..	Dec. 21	72	Fairly plentiful ..	,, ,,	—	Dry, hot, windy.
Second St.	Dec. 21	72	A littls		—	,, ,, ,,
Signal Road ..	Dec. 21	72	,, ,,	Plentiful ..	—	,, ,, ,,
Blignaut St. ..	Dec. 21	72	,, ,,		—	,, ,, ,,
Blignaut St. ..	Dec. 23	48	Fair	Fairly plentiful ..	—	,, ,, ,,
Signal Road ..	Dec. 23	48	Fair	Plentiful ..	—	,, ,, ,,
Ramblers Club ..	Dec. 23	48	,,	Fairly plentiful ..	—	,, ,, ,,

*This description may seem anomalous for a day on which 0·65 inches of rain is recorded as having fallen, but a maximum temperature of 84°F, and a difference of 16°F. between wet and dry bulb readings, suggests heat and dryness. The effect of the rain is evident on the readings for the following day. It no doubt fell at night.

Second Street.—This is in the central part of the town, and pepper trees are fairly plentiful in the neighbourhood. This site was chosen because it was the residence of two patients who were suffering from hay fever. The plates were hung on the stoep. The pepper tree nearest to the plates was 35 paces distant and to the east (that is, the leeward with reference to the prevailing wind). The nearest pepper trees in other directions were much further off. It will be noticed from the Table that of eight plates suspended here, pepper tree pollen was found on seven, and no other pollen on any.

TABLE IX

METEOROLOGICAL OBSERVATIONS: BLOEMFONTEIN, NOVEMBER AND DECEMBER, 1920.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Maximum Temperature.	Direction Wind.	Force of Wind. 0—12	Rainfall (inches).
November 20	70·5°F.	60·0°F.	90·9°F.	NNE	2	
21	74·3	62·9	91·9	N	2—3	0·00
22	69·4	63·0	84·6	NNE	1	0·05
23	69·8	62·3	91·5	N	3	0·00
24	80·1	64·1	94·1	NW	3—4	
25	77·1	61·0	84·0	S	2	0·65
26	56·0	55·2	71·5	NNE	1	0·01
27	58·1	52·0	75·1	E	2	
28	62·9	56·0	77·7	N	2—3	
29	71·1	59·3	85·5	NW	2	
30	72·1	60·0	80·2	SW	2	
December 1	65·2	56·5	81·0	NNE	1	
2	70·1	60·7	87·0	NE	1	
3	76·0	62·0	90·0	NNE	2	
4	76·1	59·8	91·9	N	2	0·00
5	82·9	61·0	94·5	N	2	
6	78·4	60·2	95·2	N	2—3	
7	79·6	59·8	93·4	N	3—4	
8	78·8	60·3	93·2	N	3—4	
9	76·6	60·9	91·5	N	2	
10	77·0	61·8	92·9	N.	3	0·00
11	78·4	63·1	94·5	NW	3	
12	75·8	63·0	93·1	NNE	3	
13	73·0	61·8	89·9	WNW	2	
14	67·6	55·8	85·4	ENE	3—4	
15	67·0	57·6	87·8	N	3	0·26
16	69·9	61·0	81·5	E	2	
17	75·9	61·9	87·7	N	2—3	0·00
18	74·5	62·2	87·2	NW	3—4	0·00
19	60·6	52·6	74·9	NW	3	
20	72·9	59·8	82·9	SSW	2—3	
21	74·6	58·8	88·4	SE	1—2	
22	76·5	62·0	93·2	NNE	2—3	0·00
23	73·7	61·6	90·7	NNW	4	0·13
Average ..	72·4	60·0	87·5			

Signal Road and Blignaut Street are in the Railway area of the town, where, too, pepper trees are numerous. The plates were hung near residences where patients were suffering from the epidemic.

Plates dated after December 20 were examined direct: the others after centrifuging. Table IX gives the meteorological observations covering the period during which plates were exposed.

(*c*) *Bloemfontein, November and December, 1921, and General Remarks on the three years' results.*

During the epidemic season of 1921 plates were exposed at Bloemfontein over a period of 13 days between November 14 and December 6. Particulars are given in Table X and weather records for the same period in Table XI. The plates were exposed in pairs, on one occasion in triplicate, on the balcony of the Ramblers' Club, some 28 feet above the ground. This site, as has already been explained, is central and fairly typical of regions of the town where pepper trees are plentiful. The two situations in which plates were regularly hung were respectively 40 and 16 paces from the nearest pepper tree.

Dust and pepper tree pollen were found on all the slides, and no other pollen, ignoring single grains, was found on any. Examination was after centrifuging.

TABLE X

EXPOSURE OF POLLEN PLATES: BLOEMFONTEIN, NOVEMBER AND DECEMBER, 1921.

Place of Exposure.	Date.	Duration of Exposure (hours).	Dust.	Pepper Tree Pollen.	Other Pollen.	Comments. on Weather.
Ramblers Club	Nov. 17	72	Fairly plentiful	Fairly plentiful	—	Hot, fairly calm
Ramblers Club	Nov. 25	72	Very plentiful	Very plentiful	—	Hot, windy.
Ramblers Club	Dec. 2	72	Very plentiful	Very plentiful	—	Hot, windy.
Ramblers Club	Dec. 6	96	Fairly plentiful	Fairly plentiful	—	Hot, calm.

It will be noticed that at Bloemfontein during the epidemic season of 1920 and 1921 pollen plates were exposed only in areas where pepper trees are plentiful, but had pollen of any kind been generally distributed through the air of the town it, too, should have been caught on the pollen plates. The results agree generally with those of 1919 and emphasise the presence of dust and pepper-tree pollen in the air of the town. It is remarkable that during these two epidemic seasons, if varieties of pollen of which only a single grain was found on a plate be again ignored, no pollen other than that of the pepper tree was found on the plates. During these two seasons nearly all the plates were exposed at or in the vicinity of the Ramblers' Club, a centre at which the monotony of the pollen content of the air has already been commented on in discussing the 1919 results. In fact, from the point of view of pollen statistics, the air of Bloemfontein generally would have been extraordinarily dull in these seasons but for the pepper tree.

The scarcity of pollens other than that of the pepper tree in the air of the town is probably to be attributed to the distribution of the rainfall and the nature of the vegetation in the vicinity of the town. The vegetation to the west of the town (the direction from which the prevailing strong winds blow during the epidemic season) is almost pure grass, the flowering of which is determined by rain. Though growing rains may fall in the early summer, it is usually not until February that the rain is sufficient to enable the grass to flower on a large scale. The vegetation of the kopjes to the north and north-east of the town is more varied, and includes some shrubs whose flowering season, though also dependent on the rain, is less so than that of grass; but strong winds from this direction are rare.

The weather, apparently chiefly the rainfall, also exerts a great influence on the date and profusion of flowering of the pepper tree, an exotic which is cultivated in gardens and in the streets. In the three seasons 1919-1921 it came into flower towards the end of October, and simultaneously epidemic hay-fever commenced. The principal flowering season of the pepper tree is November and December, and it is in these months that the epidemic is most severe.

A reference to Table II will show that the hay fever epidemics occur towards the end of a long dry season. Thus, in 1919 the total rainfall at Bloemfontein for the six months May—October was only 1·96 inches.

Though the results of an examination of the air of Bloemfontein for three consecutive epidemic seasons are in general agreement in emphasising the presence of dust and pepper tree pollen and the virtual absence of other pollens, it is probable that observations over a series of years would show the kinds and quantity of native pollen in the air at this season to vary from year to year, and to be determined chiefly by the rainfall. Thus, with heavy rains in early spring, extensive areas of grass will flower in December, and grass pollen would then be expected in the air.

It should be noted that no pollen of any of the American hay-fever weeds (Scheppegrell, 1916) was found on the pollen plates. Many species of them occur as weeds in and around the town, but they never flowered freely during any of the three epidemic seasons in which pollen plates were exposed. They are mostly annuals whose flowering, like that of grass, is dependent on the rains. With repeated heavy spring rains they, too, might be expected to flower during the epidemic hay fever season.

IV. Is Pepper Tree Pollen Capable of Causing Hay Fever?

This was tested in two ways: (a) By what is known as the Cutaneous Test. This is the standard method of testing susceptibility to a particular pollen, and consists of scarifying the skin, of, say, the arm, and applying to it the neat pollen. The reaction, if any, is local. In nature, hay fever pollens are inhaled, but patients hesitate to inhale pollen in an experiment, as the result, if the patient is susceptible to the variety of pollen used, is to

bring on a severe attack of hay fever. In these tests (Potts, 1921) nine patients susceptible to the epidemic reacted strongly, or very strongly, to neat pepper tree pollen, whereas five non-susceptible persons used as controls gave no reaction.

All these patients had been resident in Bloemfontein during several epidemic seasons, the controls without having suffered from the affliction, whilst the susceptibles had suffered severely every season. Each class was suitable for the purpose intended.

(b) By inhaling the pollens. A severe attack of hay fever was induced in three patients susceptible to the epidemic by inhaling the pollen through the nose. Two of these cases have already been recorded (Potts, 1919). No controls, non-susceptibles, were used. Two of these patients were tested cutaneously with the neat pepper tree pollen on another occasion, when each reacted strongly.

Pepper tree pollen is, therefore, capable of causing hay fever in persons susceptible to these epidemics. As this pollen occurs in the air of the town during the epidemic season (and is, practically speaking, the only pollen which does so occur) it must be inhaled by these patients, and is no doubt the cause of their sufferings. Being in the air of the town pepper tree pollen must also be inhaled by non-susceptible persons, but they are immune to this particular poison.

V. Pollens in the Nasal Secretion of Patients Suffering from Hay Fever during the Epidemic.

If virtually only one kind of pollen is occurring in the air and patients suffering from hay-fever are shown to be sensitive to it, this is probably sufficient proof that this particular pollen is responsible for the hay fever. But, as a further check, the nasal secretion of patients suffering from the epidemic was examined for pollens. It should be explained that when pepper tree pollen is mounted in nasal secretion, the majority of the grains, which are oval in outline and have a conspicuous groove along one side, swell to a varying degree, lose their groove, become spherical and usually burst. As the wall of this pollen is smooth and devoid of any markings the grains in this swelling lose the characters (size, shape and groove) by which they can be identified as belonging to the pepper tree. The secretions, which had been discharged on to a glass sheet as soon as the patient awoke, and which had solidified, were first examined direct but without showing any pollens. They were then dissolved, centrifuged, concentrated to a small bulk, and re-examined, when pepper tree pollen was found in all of them. The number of secretions examined was four, from different patients, and the number of grains of pepper tree pollen unswollen, or so little swollen as still to be identifiable, found in them was respectively 7, 6, 4 and 2.

It was, perhaps, not very surprising to find pepper tree pollen in the nasal secretion, as pollen plates exposed in the part of the town where these patients slept showed pepper tree pollen

to be in the air. It must, therefore, have been inhaled by everyone, whether susceptible or immune. What is, perhaps, at least as important is that no other variety of pollen was found in these secretions, and had they occurred they would probably have been detected, as the majority of pollens have spicules or other markings by which they can be identified whether unswollen or burst. These examinations were made in December, 1920, and the only pollen found on pollen plates at the time was that of the pepper tree.

VI. Sterility of Pepper Tree Pollen.

Careful bacteriological examination of the flowers of the male pepper tree by Mr. O. F. Gibbs, Bacteriologist in the Public Health Department, showed the interior of the unopened flower buds, including the pollen, to be bacteriologically sterile. The pollen, therefore, plays no special part in introducing the bacteria found in the nasal discharge of patients suffering from hay-fever. (*Vide* Potts, 1919.)

VII. Shape and Size of Pepper Tree Pollen.

The pollen grains of the pepper tree are oval in outline with somewhat truncate ends, and have a smooth surface, free from spines or other outgrowths. Their most conspicuous feature is a prominent groove running along one side. In general shape they bear a striking resemblance to a grain of wheat. Their size varies as a rule between 33 to 37 microns long by 14 to 18 microns broad, most of them being of the order 33 microns long by 17 microns broad. It should be noted that pepper tree pollen is somewhat larger than the majority of pollens that have been found to cause hay fever elsewhere.

VIII. Pollination of the Flowers of the Pepper Tree.

It has already been explained that the flowers of both male and female trees produce nectar in abundance, and that the pollen (in newly-opened flowers) and stigma are sticky. These characters and the showy corolla would lead one to expect pollination by animals. Insects, especially flies, frequent the flowers. Some insects caught visiting the flowers were identified at the South African Museum, Capetown, by the courtesy of the Director, Dr. L. Peringuey, as follows:—

Musca domestica L.—The common house fly.

Paratrycyclea stabulans Bez.—A fly.

Chortophila cilicrura Rond.—A syrphid fly.

Dacus binotatus Loew.—A fruit fly.

Stomoxys calcitrans L.—Stable fly.

A Ceratitid (Fruit) fly.

Xanthogramma ægyptium Wied.—A wasp.

Apis mellifica var *andersoni* Higs.—Honey bee.

All these insects when caught had a yellow powder sticking to the body which, when examined under the microscope, proved to be the pollen of the pepper tree. There is, therefore, no reasonable doubt that the flowers are pollinated by insects (*vide* also the section dealing with the drying of the pollen).

IX. Effect of the Weather on the Drying of the Pollen of Pepper Trees and on the Opening and Shedding of the Male Flowers.

1.—*Drying of the Pollen.*

In view of the fact that a preliminary examination of the flowers of the pepper tree had shown that they had all the characters of typical insect-pollinated flowers (Potts, 1919), and, in particular, had moist sticky pollen, it was a very great surprise to find when pollen plates were exposed during the next available epidemic season that not only was pepper tree pollen present in the air, but that it was there in large quantities. This necessitated a re-examination of the flowers of the tree. This was done in November, 1919, in hot dry weather, when it was found that the pollen of many of the flowers still on the tree was dry and powdery, and could easily be shaken out, and that the anthers were in varying stages of emptiness, some being still full of pollen whilst others were nearly empty. Fallen flowers from the ground yielded similar results; those still fairly fresh contained more or less pollen, whilst the dry withered flowers, which had presumably been longer on the ground, had empty anthers. In other words, there was evidence in both cases of the gradual disappearance of the pollen into the air. Also, if cut shoots are placed in water in such weather the pollen gradually falls from the anthers, and may be collected in considerable quantities.

Further experience showed that in cool, moist weather, the pollen remains sticky, in fact, becomes increasingly so, whereas in hot, dry weather it becomes dry and powdery. When the initial examination of the flowers was made in the autumn of 1918 the weather was cool and moist; and Bloemfontein was enjoying a spell of the same kind of weather when it was necessary to collect pollen for the purpose of the cutaneous tests. The difficulty then experienced in separating the sticky pollen from the flower has already been recorded (Potts, 1921), but it may be recalled that this was finally effected by rolling the open male flowers between sheets of plate glass to which the pollen adhered, and from which it was removed with a razor.

It is very difficult to separate the effect of heat from that of dryness in drying the pollen under natural conditions in the open air, as in Bloemfontein during the flowering season of the pepper tree very hot weather is almost invariably parchingly dry. Simple laboratory experiments also left considerable doubt regarding the question. They showed that a high temperature and dry air are both favourable to the drying of the pollen, but that the process seems to be complicated by other undetermined fac-

tors. If once pollen has been allowed to become really sticky, it is not dried by heating in an incubator in dry air at maximum summer shade temperatures in Bloemfontein.

If pepper tree pollen from a freshly opened anther be examined under the microscope, it will be found that the grains are stuck together by an oily yellow liquid. This liquid is soluble in ether and gives the other recognised reactions for essential oils, and contains in solution the yellow pigment to which the colour of the pollen is due. It seems probable that in cool moist weather the essential oil is gradually changed to a resin, but that in very hot weather it evaporates before this change can take place, and hence the pollen becomes powdery. The weather may also influence the nature of the oil formed by the plant. But, whatever be the reason, it is a directly observable fact that in very hot dry weather the pollen becomes dry and powdery, and so can be dispersed by the wind, whereas in cool moist weather it remains sticky.

The drying of the pollen in the hot dry weather, so characteristic of Bloemfontein during the epidemic season, is the explanation why it is possible for the pepper tree to cause hay-fever. As far as I am aware, a similar change in the character of pollen has not been previously recorded; nor has it been shown that an insect-pollinated plant can cause hay fever to a serious extent.

My colleague, Mr. F. Zweerts, who has already had experience in research work on essential oils at Delft, has expressed the intention of investigating the question further next season. The problem is a little research in itself.

Some of the wind-blown pollen of the pepper tree must also fall on the stigma of the flowers of this plant, but it is difficult to gauge the importance of wind as an agent of pollination here.

Incidentally, it may be mentioned that occasional grains of the pollen of several cultivated insect-pollinated plants were found on the pollen plates. On one occasion snapdragon pollen was found on a plate suspended in a second floor window some 29 feet above the ground, and at a distance of some 110 paces from the nearest snapdragon plant. It may be that many pollens which remain sticky in the original home of the plant become dry and are dispersed by the wind in very hot dry climates.

2.—*Opening and Shedding of Flowers.*

Usually, while the male pepper tree is flowering, the flowers are continually being shed from it, and the ground beneath a large male tree in full bloom is sometimes almost cream in colour from the fallen flowers, which are shed, as a rule, soon after opening, and whilst the petals are fresh and there is still some pollen in the anthers. But, after a continuance of hot dry weather such as is prevalent during November and December in Bloemfontein, flowers cease to be shed and the flower-buds remain unopened on the trees. This happened with some trees I

had under observation during the first half of December, 1920. But on the 15th of the month there was a very slight shower (0·26 inch was recorded half a mile off), not sufficient to moisten the soil deeper than one quarter of an inch, yet on the 17th open male flowers were again being shed in profusion, and the ground was sprinkled with them to the extent of a thick seeding.

TABLE XI

METEOROLOGICAL OBSERVATIONS: BLOEMFONTEIN, 1921.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Maximum Temperature.	Direction of Wind.	Force of Wind. 0—12	Rainfall (inches).
November 1	60·7°F.	51·6°F.	78·8°F.	W	3	
11	57·1	49·0	63·2	S	5	
12	53·0	43·6	60·1	S	5	0·23
13	52·8	46·4	65·3	SE	3	
14	54·2	46·2	74·1	N	3	
15	64·7	48·7	79·8	NW	2	
16	64·6	49·5	82·5	NE	3	
17	67·7	58·0	84·5	N	4	
18	72·5	53·4	88·6	N	2	
19	71·3	60·2	83·6	NE	2	0·04
20	69·0	58·9	84·2	N	3	0·00
21	71·7	58·8	85·2	N	4	0·01
22	69·1	60·5	85·2	SE	2	0·43
23	65·1	59·6	77·1	NE	4	0·01
24	65·0	58·7	76·4	N	3	0·03
25	68·5	62·2	79·5	N	2	0·00
26	66·3	60·7	79·6	NE	3	0·04
27	71·6	62·3	86·7	N	2	0·01
28	70·8	59·6	85·1	N	1	0·05
29	64·8	57·0	77·8	N	3	
30	66·3	58·0	83·6	N	2	
December 1	75·3	59·5	87·8	N	3	
2	76·6	60·7	89·4	N	4	
3	71·3	59·9	89·8	N	4	
4	77·7	62·5	90·5	N	4	0·17
5	61·1	60·6	67·5	SE	2	0·02
6	66·2	60·9	77·4	S	2	0·10
Average ..	66·5	56·6	80·1			

The weather records for this period will be found in Table XI, but it should be remembered that the readings are taken at 8.30 a.m., before the dry westerly wind springs up. The fact that such a small quantity of rain can result in the opening and shedding of the flowers would suggest that the moistness of the atmosphere, rather than the supply of water to the roots, is the controlling factor. Experiments with cut shoots placed under bell glasses, the humidity of the air in which was regulated, showed that a very dry atmosphere prevents the flower buds from opening, and that a moist and even saturated atmosphere

is favourable to their opening. When such a shoot with open flowers is very slightly shaken, as would be caused in nature by a light breeze, the open flowers fall freely.

Further observation confirmed the original experience, but also showed that all the trees of a neighbourhood do not cease to shed their flowers at the same time. Thus, after a continuance of hot, dry weather, large trees which, presumably, have access to water—for example, in some gardens—continue to shed their flowers for several days after the smaller, less favoured trees—for example, growing on the streets—have ceased to do so.

In the case of the female tree, only the petals and staminodes are shed, and, as these organs are very small and each falls separately, they are not noticed on the ground.

In response to a circular letter distributed to epidemic sufferers in Bloemfontein regarding their experiences, it was noticed that, whilst many expressed the opinion that rain gave them relief, about an equal number stated that their symptoms were aggravated after rain. The former experience was only to be expected, as rain is understood to wash pollen out of the air and to wash away or, at least, lay the dust. The latter opinion, though, is surprising and unusual, I believe, but it was expressed by so many sufferers, and frequently with such conviction, as to leave no doubt that there must be a basis of truth in it. The observations regarding the opening of the flowers suggest an explanation. A light shower after a continuance of hot dry weather may allow the flowers to open, and so increase the amount of pollen in the air, and thus aggravate hay-fever symptoms; whilst a heavy rain, by washing the pollen from the air and dust from the streets, and by causing a short spell of cool, moist weather, and therefore sticky pollen, gives temporary relief.

The observations may also explain the absence of pepper-tree pollen from the pollen plates in hot, dry, windy weather, that seems suitable for the dispersal of this pollen; the flower buds may have ceased to open. In cool, moist weather, the flowers open, but the pollen remains sticky. After a long spell of hot, dry weather, the flower-buds cease to open, so that in neither case does the pollen find its way into the air. It seems probable, in the light of these observations, that the greatest amount of pollen would be expected in the air in hot, dry, windy weather, with occasional light showers. The showers allow the flowers to open, the hot, dry air dries the pollen, and the wind can then disseminate it. In point of fact, meteorological records show that this is the kind of weather usually prevalent in Bloemfontein during the epidemic season, though we seem to hardly notice the light showers (*vide* Table III).

How much of the pepper tree pollen floating in the air comes directly from the trees, and how much from the flowers after they fall, cannot be estimated.

X. Toxicity of the Leaves and Flowers of the Pepper Tree.

Owing to the dry climate of Bloemfontein, and to the fact that the pepper tree sheds its leaves continually through the dry season, the power of the leaves and flowers (whose falling has already been referred to) to cause hay fever becomes of importance. In a moister climate these organs would soon be converted into vegetable mould and stick to the moist ground, or be smothered by grass and weeds, and not find their way into the air again. But in Bloemfontein, during the dry season, there is not sufficient moisture for decay to take place. The flowers and leaves merely become dry and brittle, are trodden underfoot, and become ground down and mixed with the general dust of the road. At this season, too, the surface of the ground is bare and dry, so that powdered material is easily caught up by the wind.

Some of the dust on the pollen plates was of vegetable origin, and although none could be identified as belonging to the pepper tree, there is no reasonable doubt that this material must be distributed by the wind along with mineral dust.

The toxic principles contained in pepper tree pollen may also occur in other parts of the plant; and, as the fallen leaves and flowers are merely preserved dry without undergoing bacterial decomposition, it seems not unlikely that any such poisonous principles present would remain unchanged.

The toxicity of the dead leaves and flowers was tested by the cutaneous test, as had been done with the pepper tree pollen. The results are shown in Table XII.

Dead fallen leaves were collected, probably from trees of both sexes, and ground. The flowers used were from female trees, to ensure the absence of pollen, and the material was dried and also ground. The pollen was collected in the manner already described (Potts, 1921); and the reactions it gave indicate the susceptibility to epidemic hay-fever, though the terms " susceptible " and " non-susceptible " refer really to whether the patient suffers or is free from hay fever in Bloemfontein during the epidemic season. The normal saline was merely a control inoculation.

With one exception, in the case of the leaf tests, all the susceptible patients who reacted to the neat pollen also reacted to both leaves and flowers, though much less severely. On the assumption that hay fever symptoms are induced by toxic proteids, a reduced virulence of leaf and flower would be expected, as the pollen grains contain a much larger proportion of protein matter than is contained in leaf and flower, whose bulk is largely made up of cell walls, empty cells, and intercellular spaces.

The three patients who have not suffered from hay fever gave no reaction except to the leaves, to which they all reacted very slightly. The reaction of these patients to the leaves but not to the flowers or pollen is difficult to understand. The absence of a reaction to the pollen would show that they are not

TABLE XII

TOXICITY OF LEAVES AND FLOWERS OF THE PEPPER TREE.

Patient.		Susceptibility to Epidemic Hay-Fever in Bloemfontein.	Reaction to the following when applied to the scarified skin.			
No.	Name.		Neat Pepper Tree Pollen.	Pepper Tree Leaves.	Female Flowers of Pepper Tree.	Control Solution (Normal Saline).
1	Mr. D.	Susceptible	Severe	Very mild ..	Very mild ..	Nil.
2	Mr. R.	,,	,,	Mild	Fairly mild ..	Nil.
3	Mrs. du T. ..	,,	,,	Very mild ..	Moderately severe	Nil.
4	Mrs. G.	,,	,,	Nil	Mild	Nil.
5	Mrs. H.	,,	,,	Mild	Medium	Very slight.
6	Mr. P.	,,	,,	Fairly severe ..	Fairly severe ..	Nil.
7	Mr. L.	Not susceptible ..	Nil	Very slight ..	Nil	Nil.
8	Mr. K.	,, ,,	,,	,, ,,	,,	Nil.
9	Mr. C.	,, ,,	,,	,, ,,	,,	Nil.

susceptible to the hay fever toxins of the pepper tree, as is also indicated by their freedom from hay fever in Bloemfontein during the epidemic season. The leaf-reaction may be due to the resin present, which other experience proved to be a powerful irritant.

In the light of these tests it would seem probable that the toxic principles, which induce hay fever in persons susceptible to pepper-tree pollen, are present to a small extent in parts of the flower other than the pollen; but that neither flowers free from pollen, nor leaves, are of any practical importance in intensifying the local epidemics.

The results are in agreement with the experience of epidemic sufferers, who find that the commencement of their hay fever synchronises with the coming into flower of the pepper tree on a large scale. If the leaves played an important part in causing hay fever, symptoms would be expected earlier. The results have also an important bearing on prevention, as if the epidemic trouble is virtually all due to the pollen of the pepper tree it could be prevented by removing the male tree.

XI. Pollens in the Air of Bloemfontein during the Rainy Season, 1920.

The epidemic hay fever season at Bloemfontein extends from about the last week of October until into January (or even later, depending mainly on the rains), and is usually worst during November and December. Tables showing the results of exposing pollen plates at Bloemfontein during the epidemic have already been given. For comparison, plates were exposed at Bloemfontein in March, 1920. The results are given in Table XIII, and the meteorological observations for the same period in Table XIV.

The University College Grounds are to the west of and beyond the town. The vegetation in them is typical grass veld, and there were no pepper trees near the place of exposure of the plates. Corresponding particulars regarding the other centres have already been given in connection with the other tables.

A total of 11 plates were exposed for varying periods between March 19 and April 1. On seven of them grass pollen was found, the amount present being in one instance equivalent to density of 55 pollens per sq. centimetre per 24 hours. No pollen other than grass pollen, not even that of the pepper tree, was found on any of the plates. The pollen-content of the air is, therefore, very different from that of November and December. But heavy rains had fallen. The pepper tree had entered on a period of intense vegetative activity, having produced an abundance of new, green, leafy shoots, and had almost ceased to flower. Moreover, in the comparatively few flowers produced, the pollen remained sticky and still filled the anthers of quite old flowers. The rains had also caused the grass to grow vigorously, and many kinds covering extensive areas around the town were in flower. The weather was also very different. It was cooler, moister and

TABLE XIII

EXPOSURE OF POLLEN PLATES: BLOEMFONTEIN, MARCH, 1920.

Date of Exposure.	Place of Exposure.	Duration.	Weather.	Results.
March 19th... ..	Univ. Coll. Grounds	72 hours	Windy at times, also rainy. Cool.	Dust plentiful; one kind of grass pollen, fairly plentiful.
March 19th... ..	Bloemfontein Club	72 hours	,, ,,	A little dust; a few grass pollens of one kind.
March 19th... ..	Ramblers Club ..	72 hours	,, ,,	Many dust particles; no pollen.
March 26th... ..	Univ. Coll. Grounds	72 hours	Showery; a cold wind blowing part of the time.	A little dust; no pollen.
March 26th... ..	Bloemfontein Club	72 hours	,, ,,	,, ,,
March 26th... ..	Ramblers Club ..	72 hours	,, ,,	,, ,,
March 30th... ..	Bloemfontein Club	96 hours	Cool and calm	No dust; one kind of grass pollen, plentiful.
March 30th... ..	Univ. Coll. Grounds	72 hours	,,	Very little dust; grass pollen very plentiful, 47 grains counted, equivalent to a density of 55 per sq. cm. for 24 hours.
April 1st	Bloemfontein Club	48 hours	Calm, fairly hot	Dust plentiful; grass pollens fairly plentiful.
April 1st	Univ. Coll. Grounds	48 hours	,, ,,	A little dust, a few grass pollens.
April 1st	Ramblers Club ..	72 hours	,, ,,	,, ,,

less windy. Soft balmy breezes replaced the hot, dry, parching, westerly wind. There was also very little dust. In fact, the weather was distinctly pleasant. There was also very little hay fever, and the cases were mild in type as compared with those during the epidemic season. The weather, state of the vegetation and position regarding hay fever as just described, are fairly typical for this period of the year in Bloemfontein. It was the rainy season, and good growing rains had fallen at sufficiently short intervals to keep the natural vegetation (grass) growing vigorously and allow it to flower.

It is concluded that the little hay fever about was attributable to grass pollen. Some of the patients now suffering also suffer during the epidemic season; others are free from the trouble until the grass begins to flower. The conclusion is drawn that the former are susceptible to both pepper tree pollen and grass pollen, whereas the latter suffer from grass pollen but not from pepper tree pollen.

From Table II it will be seen that 16.36 inches of rain fell at Bloemfontein during the first three months of 1920, as compared with 4.41 for the preceding eight months. This should be kept in mind in comparing the results shown in Tables IV and XIII. The contrast in the rainfall of the dry and wet seasons in this case is more marked than usual, partly no doubt because 1919 had the lowest rainfall ever recorded for Bloemfontein (11.64 inches).

XII. Difficulties in Accepting the Pepper Tree as a Cause of Hay Fever.

There are three main difficulties in accepting the pepper tree as a cause of hay fever in nature: (1) it is insect-pollinated; (2) the relatively large size of its pollen; and (3) the fact that the tree occurs in other towns of the Union which are not seriously troubled with hay fever. These objections will now be considered in turn.

(1) *Insect-pollination.*

All the plants which have hitherto been shown to cause hay fever on a large scale are wind-pollinated, and a perusal of hay fever literature shows that it is an accepted principle that only such plants can cause the affliction. The explanation of the anomaly in the case of the pepper tree is, that in very hot, dry weather, such as is frequent in Bloemfontein in November and December, the pollen, which is naturally sticky, becomes dry and powdery and so can be carried by the wind.

(2) *Size of Pollen.*

It has been shown that a small particle such as a pollen grain, whilst being carried by the wind is really going through a process of falling, and that it is doing so with a uniform velocity rather than an acceleration. The relative velocity of fall of smooth spherical pollens through the air may be taken, for prac-

TABLE XIV.

METEOROLOGICAL OBSERVATIONS: BLOEMFONTEIN, 1920.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Maximum Temperature.	Direction of Wind.	Force of Wind. 0—12	Rainfall (inches).
March 15	69·5°F.	61·0°F.	80·1°F.	NE	1	0·41
16	65·5	60·9	78·8	SW	1	0·01
17	66·3	60·1	78·2	SSE	1	
18	64·0	59·4	77·2	NE	1	
19	63·9	58·0	76·8	N	3	
20	61·5	57·9	73·9	NNE	1	0·90
21	57·9	56·1	70·0	SE	1	
22	57·0	54·0	72·6	ESE	1	0·30
23	57·0	56·1	63·9	SSE	1	0·12
24	58·7	56·1	68·2	W	1	0·00
25	61·5	57·3	72·8	WNW	1	
26	49·1	42·2	61·0	SSW	2—3	
27	52·0	44·9	69·1	SE	1	
28	59·0	50·1	73·0	SSE	2	
29	60·3	54·8	75·9	ENE	2	
30	61·5	55·9	76·3	E	1	
31	62·0	55·1	73·3	SSE	1	
April 1	61·7	55·0	77·3	E	1	
2	62·1	53·0	78·9	SSE	1	0·00
Average of the 19 days	60·6	55·2	73·5			

tical purposes, to depend only on the size of the pollen grain, and to vary directly as the square of the diameter of the grain. The larger the pollen, the greater the velocity of fall and, therefore, the shorter the distance to which it can be carried by the wind before reaching the ground. The size of the pollen is, therefore, a very important factor determining the area over which it is distributed, and hence its power to produce hay fever. Thus, the majority of plants that have been found to be serious causes of hay fever have small pollen, that of the Giant and Common Ragweeds (*Ambrosia trifida* and *A. elatior*, for instance, two of the commonest hay fever plants in America, being respectively 20 and 15 microns in diameter. Compared with these pollens, that of the pepper tree, which is usually some 33 microns long by 17 microns broad, is very large and therefore less buoyant. The area over which part of it is distributed must be still further reduced by the circumstance that some of it leaves the anther before it is quite dry, and whilst the grains are still partially stuck together. This is apparent from the fact that the grains of pepper tree pollen found on the pollen plates were frequently in small groups.

On the other hand, the following facts have to be remembered in this connection: First: The plant producing this pollen

is a tree, and that the pollen therefore commences its flight at a considerable distance above the ground. The middle of the crown of a medium-sized pepper tree in Bloemfontein is probably some 25 feet high; and pollen starting at this level would be carried ten times as far as from flowers $2\frac{1}{2}$ feet high, and twenty-five times as far as from flowers only a foot high. Most hay fever pollens are produced within two or three feet of the ground.

The distance to which small particles such as pollen grains are carried by wind can be calculated from Stokes' Law. This has been done in the case of pepper tree pollen and the results are shown below. In making the calculation it has been assumed that the density of the pollen is 1, that of the air negligible, and that the grains, which are elongated in form and about 33 microns long by 17 microns broad, would fall with the velocity of spheres of 25 microns diameter, this being the mean of their two dimensions. Under these circumstances the velocity of fall would be 0·25 feet per second, and the distance to which they would be carried when blown from a height of 25 feet would be

291	feet in a	wind of	2	miles per hour
1,455	,,	,,	10	,,
2,909	,,	,,	20	,,
3,637	,,	,,	25	,,
4,365	,,	,,	30	,,

The corresponding distance for smooth spheres of 35 microns diameter are 149, 748, 1,497, 1,871 and 2,245 feet respectively. The calculations have been made by Miss D. M. Gemmell from a formula supplied by Prof. W. H. Logeman; and the distances stated are in general agreement with those given by Dr. Scheppegrell on p. 16 of "Hay Fever and Hay Fever Pollens" (1917).

The figures it should be stated apply to level ground, and, in view of the uncertainty regarding the assumptions made, are to be regarded only as rough approximations.

A rough idea of the extent to which the height at which pepper tree pollen is produced compensates for its large size may be given by making a comparison with a well-known hay fever plant, having very small pollen. Assuming that the elongated grains of pepper tree pollen fall with the velocity of smooth spheres of even 35 microns diameter, the result of starting from a height of 25 feet would be that they can be carried by the same wind approximately twice as far as pollen of 15 microns (the size of the pollen of the Common Ragweed) starting from a height of $2\frac{1}{2}$ feet.

Secondly: In Bloemfontein during November and December, when the epidemic is most severe, the ground is dry and bare, so that pollen dropped by the wind can be picked up again by a subsequent gust. In this respect the conditions are vitally different from those in a moist climate, where a damp soil and covering of grass and weeds would prevent fallen pollen from

being carried further. As a matter of fact, in experiments intended to ascertain the distance to which pepper tree pollen is actually carried by the wind, it was found on plates suspended 1,000 yards (paces) from the nearest pepper tree.

Thirdly: In Bloemfontein the pepper tree is grown as an ornamental plant, both in gardens and on the streets, and in many parts of the town is very plentiful. This will be apparent from a table given in the next section, showing the results of counting the number of trees on measured areas of the town. Some 2,128 pepper trees were counted and the density was found to vary from 1 tree per 449 square yards to 1 per 214 square yards. The latter figure is fairly typical for areas of the town where the tree is dense and is based on a count of 704 trees. The circumstance that the pepper tree is so plentiful in many of the residential parts of the town is a most important factor in connection with the epidemics, and makes the case fundamentally different from the usual one, where the plant producing the hay-fever pollen is growing wild outside the town. It removes the need for buoyant pollen and also explains why the pollen in the air of the town was found to be so dense. For Dr. Scheppegrell has shown, by the exposure of pollen plates, that pollen scatters rapidly as it is carried by wind from the parent plant, and that, roughly, the density of a pollen in the air varies inversely as the square of the distance from the plant producing the pollen. For example, at a distance of 100 feet from a source of pollen the amount of that pollen in the air would be, roughly, 25 times as great as at a distance of 500 feet. Also, as Dr. Scheppegrell has already shown, it is the density of a pollen in the air which determines whether a patient shall suffer from hay fever. Everyone can inhale a certain amount of pollen without inconvenience, and suffering only occurs when the amount of pollen inhaled is in excess of the patient's neutralising power. Hence arises the vital importance of proximity to a source of hay fever pollen.

XIII. Comparison of Bloemfontein with other Towns in which the Pepper Tree Occurs.

In Kimberley, as in Bloemfontein, the pepper tree has been planted freely on the streets of the town, and there, too, epidemics of hay fever occur when the tree is in flower, which is about the same season as in Bloemfontein. On the other hand, there are other towns in the Union, notably Grahamstown, Maritzburg and Johannesburg, where pepper trees occur, which are not troubled with serious hay fever when the tree is in flower. The absence of hay fever from the three latter towns would seem to cast doubt on the conclusion that the pepper tree is the cause of the epidemics in Bloemfontein, and demands investigation. The most probable explanations are, either that the pollen does not find its way into the air of these towns, or if it does so, then it is not in sufficient quantity to cause hay fever to a serious extent.

With a view to throwing light on this difficulty, pollen plates were exposed in Kimberley, Grahamstown, Maritzburg and Johannesburg when the pepper tree was in flower, and information was collected regarding the number and density of their pepper trees, for comparison with similar data from Bloemfontein.

(a) *Number of Pepper Trees in Various Towns and Their Density.*

Steps were taken to count the number of pepper trees on measured areas of the five towns under comparison, and the following are the results:—

BLOEMFONTEIN.

Area in sq. yards.	No. of pepper trees counted.	Density.
140,178	312	1 tree per 449 sq. yds.
200,000	472	1 ,, 423 ,,
72,100	206	1 ,, 350 ,,
60,480	257	1 ,, 235 ,,
41,296	177	1 ,, 233 ,,
150,840	704	1 ,, 214 ,,
Ttl. 664,894	Total 2,128	

KIMBERLEY.

Area in sq. yards.	No. of pepper trees counted.	Density.
114,466	140	1 tree per 818 sq. yds.
195,555	352	1 ,, 555 ,,
136,488	301	1 ,, 453 ,,
126,082	318	1 ,, 396 ,,
20,667	107	1 ,, 193 ,,
Ttl. 593,258	Total 1,218	

All the areas in these two towns were blocks of streets except the last one in the Bloemfontein list, which includes only a single street (Aliwal Street). The three first-named areas in each town were selected as areas of average density (in parts of the town where the tree occurs), the others representing dense areas. In view of the fact that the areas in which the trees were counted form only a small fraction of the total area planted with pepper trees, it will be seen from the table that in both towns the tree is very numerous; and the figures in the third column show that in certain areas it is also very dense.

Grahamstown seems to rank next to Bloemfontein and Kimberley in order of density. There the total number of pepper trees in the whole town is only 470! From Maritzburg it was reported that " there are very few of these trees . . . . . so few in fact that it is felt that tabulated returns such as asked for . . . would not be of much use. There is only one stretch of pepper trees in the public thoroughfares, and the total number of pepper trees in the area referred to is only 100." Repeated requests to the Municipality of Johannesburg for corresponding data have been without avail. From other sources I am given to understand that there are considerable numbers in certain suburbs, such as Doornfontein, but figures are necessary to make a comparison possible.

The information originally received regarding the number of pepper trees in Maritzburg and Grahamstown (Potts, 1919) proves, on further inquiry, to have been somewhat misleading. Comparatively speaking, there are really very few pepper trees in these towns, and the smallness of their numbers is, no doubt, in itself a sufficient reason why the tree does not cause hay fever in them to a serious extent.

(b) *Pollens in the Air of Other Towns.*

For testing the pollen-content of the air of these other centres, in which it was necessary to send plates through the post, microslides smeared on one side were sent for direct observation, and small sheets of tin-plate of lantern-slide size ($3\frac{1}{4}$ inches square) smeared on both sides for centrifuging. In this way the risk of breakage involved in sending large plates of glass through the post was avoided. Also, where centrifuging is to be adopted, metal has the advantage over glass, that the plates can be suspended safely from one corner and thus swing freely and offer a sticky surface to the wind, irrespective of the direction from which it blows. The results given by the two methods were in agreement. The word plate is used as a general term to cover both microslide and metal sheet.

Kimberley.

In all, 28 plates were exposed in various parts of Kimberley during ten days in the first half of December, 1920, when, as reported by four local doctors, a severe epidemic of hay fever was raging. The period of exposure varied from 12 to 72 hours, and the weather was described as being hot, dry and windy during most of the period. The wind, it is understood, was of the same dry, westerly type already described for Bloemfontein at this season. Weather records for the month are given in Table XV. The mean maximum temperature and mean difference between the wet and dry bulb from December 1 to December 15 were 96·6°F. and 16·0°F. respectively. The records, therefore, show great heat and dryness. Examination of the plates showed that pepper tree pollen was present in varying amounts on 22 of the 28 plates, the amount being roughly of the same order as had

frequently been found in Bloemfontein. Dust was present on all the plates and was usually very plentiful. Of the six plates on which pepper tree pollen was not found, three were reported as having been suspended "away from pepper trees." Only one other kind of pollen was found, and this was present on four plates. Its identity could not be determined, but it occurred in smaller amounts than that of the pepper tree. Again, as at Bloemfontein, dust and pepper tree pollen are the outstanding features.

TABLE XV

METEOROLOGICAL OBSERVATIONS: KIMBERLEY, 1920.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Maximum Temperature.	Direction of Wind.	Force of Wind. 0—12	Rainfall (inches).
December 1	67·0°F.	58·0	89·5°F.	NE	3	
2	74·0	59·0	94·0	E	2	
3	75·0	60·0	97·4	NE	2	
4	80·0	59·0	98·2	NW	5	
5	81·6	57·2	99·5	WSW	4	
6	79·0	57·0	100·2	N	1	
7	77·0	61·0	99·2	E	1	
8	78·0	56·0	99·0	WSW	2	
9	75·4	58·0	96·4	W	1	
10	77·4	63·0	98·6	N	2	
11	78·0	63·4	97·2	W	3	
12	76·0	60·0	97·2	NE	1	
13	73·5	63·0	95·0	SE	2	
14	66·5	56·2	93·0	NE	5	
15	74·0	61·0	86·5	N	1	1·02
16	64·5	60·0	81·0	SE	2	
17	71·0	60·2	89·0		0	
18	75·0	64·0	86·5	NNW	4	0·16
19	55·0	51·0	76·5	SW	4	
20	69·0	61·0	86·0	SSW	3	
21	71·5	58·0	94·0		0	
22	77·5	58·0	94·0	N	2	
23	74·0	63·0	95·0	W	3	
24	73·0	56·0	94·0	SW	1	
25	72·0	57·0	86·0	SW	3	
26	54·0	45·0	77·0	SE	5	
27	62·0	55·0	89·2	NE	3	
28	76·5	64·0	96·0	W	4	
29	72·5	56·0	99·0	NW	2	
30	78·0	61·0	95·0	W	5	
31	72·0	62·0	93·5	N	4	
Average ..	72·6	58·8	92·7°F.		Total Rainfall 1·18	

Grahamstown.

Plates were exposed in representative parts of Grahamstown from December 3-7, 1920, and from December 11-13, seven plates during each period. Most of them had no pollen and there was a noticeable absence of dust as compared with slides exposed

in Bloemfontein and Kimberley for the same length of time. On five of the fourteen plates, one kind of pollen was present, and, though its identity could not be determined, it was not that of the pepper tree. Its presence indicated that, during part of the period of exposure the weather, which on three of the days of exposure was reported as very hot and windy, had been suitable for the dispersal of at least that kind of pollen. From reports received from four doctors, it appeared that there was no hay fever about at the time and that hay fever is never prevalent there, though one doctor reported having, in his own mind, "traced two cases of acute conjunctivitis to pepper trees." No pepper tree pollen was found on any of the plates. Weather reports for the month are given in Table XVI. The mean maximum temperature and mean difference between the wet and dry bulb during the eight days of exposure were 77·3°F. and 7·1°F. respectively.

TABLE XVI

METEOROLOGICAL OBSERVATIONS: GRAHAMSTOWN, 1920.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Maximum Temperature.	Direction of Wind.	Force of Wind. 0—12	Rainfall (inches).
December 1	61·0°F.	54·2	72·0°F.	S		
2	61·0	50·2	79·6	S		
3	74·0	55·2	83·5	E		
4	83·5	68·5	104·8	N		
5	66·5	63·0	71·2	SW		0·12
6	61·0	54·2	65·0	S		0·20
7	60·6	59·0	82·2	E		
8	63·0	55·8	73·2	S		
9	62·4	53·8	74·4	S		
10	73·6	64·0	79·6	S		
11	64·0	60·5	69·0	N		
12	63·0	56·0	74·5	N		
13	56·5	55·6	68·0	SE		0·06
14	67·5	67·0	84·0	NE		0·01
15	66·6	63·0	71·0	SW		0·13
16	64·5	62·0	73·2	SE		
17	71·0	65·0	85·0	E		
18	73·2	68·0	77·5	S		1·46
19	63·2	62·0	70·8	SW		0·13
20	58·8	58·0	69·4	SW		
21	61·8	54·0	73·6	W		
22	68·6	62·0	75·4	S		
23	56·2	55·8	66·6	SW		
24	66·6	58·4	—	W		0·21
25	50·0	48·4	74·4	SW		0·25
26	54·4	50·0	60·4	SW		0·03
27	60·0	53·2	74·0	E		
28	66·6	61·4	76·8	E		0·12
29	64·4	64·0	67·4	S		0·37
30	66·4	59·6	81·2	E		0·03
31	65·8	61·6	70·0	SW		
Average ..	64·4	58·8	78·3		Total Rainfall 3·12	

Maritzburg.

Unsettled weather with heavy thunderstorms daily in the afternoons was reported as having delayed the exposure of pollen plates at Maritzburg; but, eventually, 12 plates were exposed in various parts of the town towards the end of December, 1920, and early in the following month. The pepper tree was in flower at the time, but reports from doctors showed that there was little or no hay fever. No pepper tree pollen and very little dust were found; but one other kind of pollen, whose identity could not be determined, was plentiful on three of the plates. The weather records for December are given in Table XVII.

TABLE XVII

METEOROLOGICAL OBSERVATIONS: MARITZBURG, 1920.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Maximum Temperature.	Direction of Wind	Force of Wind 0—12	Rainfall (inches).
December 1	61·0°F.	58·0	70·0°F.	SE	2	0·05
2	64·0	60·0	77·5	SE	1	
3	73·3	66·3	82·8	ESE	1	
4	76·8	68·0	94·2	SE	1	
5	82·2	70·6	82·0	ESE	4	0·17
6	61·5	61·2	64·0	SE	2	0·37
7	63·8	62·8	76·5	E	1	0·12
8	76·0	65·2	81·0	E	0	0·04
9	64·0	60·8	70·0	S	1	0·08
10	70·8	67·0	94·8	E	1	
11	75·5	69·5	83·2	E	1	0·31
12	65·8	61·4	72·0	NE	3	1·20
13	59·5	58·2	62·0	SE	1	0·36
14	60·2	56·2	70·0	S	1	
15	69·5	62·0	81·0	NE	1	
16	66·0	61·2	77·2	SE	1	
17	66·0	62·0	78·5	SE	1	
18	68·0	64·8	83·2	E	1	0·04
19	70·0	68·0	74·2	SE	1	0·41
20	73·0	64·8	80·0	ESE	1	0·27
21	62·8	58·0	67·5	E	1	0·05
22	67·5	66·2	90·0	E	1	0·11
23	83·5	70·0	87·0	NW	3	
24	70·5	67·5	82·0	E	2	
25	70·5	67·5	73·4	E	2	0·12
26	57·2	50·2	66·0	S	3	
27	63·2	54·0	72·5	S	0	
28	72·5	64·0	80·4	NE	2	0·04
29	73·0	66·0	77·0	SE	2	0·25
30	71·0	67·0	84·4	E	3	0·02
31	79·8	68·0	87·0	SE	1	0·37
Average ..	68·98	63·4	78·1		Total Rainfall 4·38	

Johannesburg.

Five slides were exposed for 48 hours each in various parts of Johannesburg on December 11 and 12-18, 1920. On the 11th

the weather was dry and breezy; rain fell during the night and the following day was windy. The pepper tree was in flower at the time, but there was little or no hay fever. No pollen of any kind was found on the slides; but there was grit present, showing that, during at least part of the period of exposure, dust had been blowing about. One of the slides was exposed within 50 yards of a male pepper tree. Another parcel of slides sent to Johannesburg met with an accident. Weather records for the month are given in Table XVIII.

TABLE XVIII

METEOROLOGICAL OBSERVATIONS: JOHANNESBURG, 1920.

Date.	Dry Bulb Thermometer.	Wet Bulb Thermometer.	Maximum Temperature.	Direction of Wind.	Force of Wind. 0—12	Rainfall (inches).
December 1	62·5°F.	56·0	75·3°F.	E	3	
2	57·8	54·0	80·0	NNW	1	
3	71·1	55·0	84·3	E	2	
4	62·0	53·0	81·0	NW	3	
5	69·8	55·0	86·0	SE	1	
6	70·8	55·0	84·2	NNW	3	
7	68·3	57·0	82·0	NW	4	
8	72·0	56·0	81·8	NW	3	0·55
9	63·0	56·4	75·9	NW	3	
10	64·8	59·5	79·2	NNW	3	0·62
11	67·2	57·2	75·8	NW	3	
12	65·1	56·0	72·9	N	3	0·30
13	62·5	58·1	74·0	NNW	3	0·00
14	60·8	54·3	75·3	E	3	
15	57·5	50·5	76·0	N	1	
16	65·0	52·9	77·8	WNW	1	
17	62·6	55·2	80·4	NNW	2	
18	66·9	58·1	80·2	NNW	1	
19	63·2	54·0	76·9	SSW	2	
20	68·1	53·0	82·0	S	2	
21	70·3	56·1	82·1	N	2	
22	64·8	60·0	79·5	NNW	2	1·17
23	61·4	58·0	72·0	NNE	2	0·05
24	67·0	59·0	77·1	NNW	3	0·13
25	63·2	59·0	76·5	NW	2	
26	57·3	46·0	77·4	SSE	3	
27	54·0	49·2	73·8	NE	2	
28	61·0	55·2	78·0	NW	2	0·01
29	64·8	56·0	82·7	NNW	3	
30	65·0	56·1	79·0	NNW	5	0·14
31	58·1	57·2	71·8	NNW	3	0·38
Average ..	64·1	55·4	78·4		Total Rainfall 3·35	

(c) *Drying of Pepper Tree Pollen in Other Towns.*

The result of exposing pollen plates in Kimberley, Grahamstown, Maritzburg and Johannesburg was that whilst pepper tree pollen was plentiful on the plates exposed in Kimberley, none was found on plates exposed in any of the other centres. The

Kimberley evidence is conclusive: pepper tree pollen obviously dries and finds its way into the air there. But the evidence for the other centres is not very satisfactory—negative evidence never is. The period of trial was short (especially in Johannesburg); and the weather, although, perhaps, fairly typical for these centres at this season, was not such as to lead one to expect much pepper tree pollen in the air. The question whether pepper tree pollen becomes powdery in these towns could only be settled by the repeated examination of flowers on the spot, or by the exposure of pollen plates over a longer period.

It is also very difficult to decide from the meteorological observations whether pepper tree pollen would be likely to become powdery in these other centres. It does so in Kimberley and Bloemfontein, but from the following tables, and from other data already given, it will be seen that, during the epidemic season, Kimberley and Bloemfontein are much hotter and drier than are the other three towns. As already explained, heat and dryness are the factors concerned in drying the pollen.

There are no records available regarding the wind, other than those taken at 8.30 a.m., which, for Bloemfontein at least, as already explained, are very misleading, but at this season, Kimberley, which is only some 100 miles from and due west of Bloemfontein, is, I understand, subject to the same hot, dry, westerly wind as is prevalent at Bloemfontein. A measure of the relative drying effect of the climate for the epidemic months at three of the centres is given in the statement which shows the evaporation from free water surfaces.

	Nov.	Dec.	Total for the two months. Inches.
Kimberley	13·60	13·06	26·66
Bloemfontein	9· 5	11· 8	21· 5
Johannesburg	7·13	6·79	14·92

The figures for Kimberley and Johannesburg are supplied by the Meteorological Office, which, however, has no data for Bloemfontein, Grahamstown and Maritzburg. Those for Bloemfontein are calculated from records taken near the Municipal dam at Mazelspoort.

The greater heat and dryness of Bloemfontein and Kimberley at this season are emphasised by the average figures for December, 1920, given in the last five columns of Table XIX. But it has to be remembered that hay fever occurs in Bloemfontein and Kimberley even in November; and the November averages for these towns are not very different from the December averages for the other three centres. Averages, however, are perhaps misleading, as pepper tree pollen is not found in the air of Bloemfontein throughout the whole of the hay fever season, but only on hot dry days. Hence it is rather with the records of individual days of such weather at Bloemfontein that the daily figures for other centres should be compared. It is then obvious,

from a mere inspection of the weather records, that there are very few days in the other three towns when the temperature and relative humidity approach those of the hot dry weather of November at Bloemfontein. But, as definite figures for the drying of the pollen are not available as a basis of comparison, it is impossible to be more precise.

TABLE XIX.

SUMMARY OF WEATHER IN FIVE TOWNS DURING DECEMBER, 1920, WITH THEIR ALTITUDE AND AVERAGE BAROMETRIC PRESSURE.

Town.	Altitude (feet).	Average reading Barometer of (inches).	Mean Max. Temp. (F)	Mean Dry Bulb (F).	Mean Wet Bulb (F).	Mean difference in Wet and Dry Bulb (F).	Total Rainfall (inches).
Bloemfontein	4,568	25·6	88·6	72·6	59·2	13·4	0·60
Kimberley	4,012	26·0	92·7	72·6	58·8	13·8	1·18
Grahamstown	1,769	28·2	78·3	64·4	58·8	5·6	3·12
Maritzburg	2,218	27·8	78·1	69·0	63·4	5·6	4·38
Johannesburg	5,925	24·5	78·4	64·1	55·4	8·7	3·35

The climate also affects the distribution of the pollen in other ways. The moister the atmosphere, the earlier the flowers fall. For example, with flowering shoots in water in a moist atmosphere, more than one-third of the flowers fall before any of their anthers have dehisced. It is likely, therefore, that the moister the atmosphere the smaller the proportion of pollen that is blown directly from the tree into the air. Pollen starting from the ground has, as already explained, a much more limited area of distribution.

TABLE XX.

SUMMARY OF NOVEMBER WEATHER AT BLOEMFONTEIN AND KIMBERLEY.

	Mean Maximum Temp. Fah.	Mean Dry Bulb Fah.	Mean Wet Bulb Fah.	Mean Difference in Wet and Dry Bulb Fah.	Rainfall in inches.
Bloemfontein, Nov. 1919 ..	79·8	66·0	56·0	10·0	1·95
Kimberley, Nov. 1920 ..	91·4	70·2	57·5	12·7	0·78

There is a striking parallelism between Bloemfontein and Kimberley. Of the five towns investigated, they alone suffer from this type of hay fever; in them alone is the pepper tree

numerous and dense; and they are the only towns in which pepper tree pollen was found in the air. They also agree in having a similar climate, and one that is very different from that of any of the other three towns. Their weather in the early summer is much hotter and drier, and more windy and dusty. The large number of pepper trees produce a correspondingly great amount of pollen, and at the season when the trees are flowering most profusely and producing pollen in the greatest quantity, the weather is such as to make it powdery, winds to disseminate it are frequent, and it falls on mucous membranes made unduly

TABLE XXI

RAINFALL.

Year.	Kimberley.	Johannesburg. (Joubert Park)
	Inches.	Inches.
1919	8·90	26·03
1920	21·44	30·50
1921	14·43	40·24
Average 1919-1921	14·92	32·257

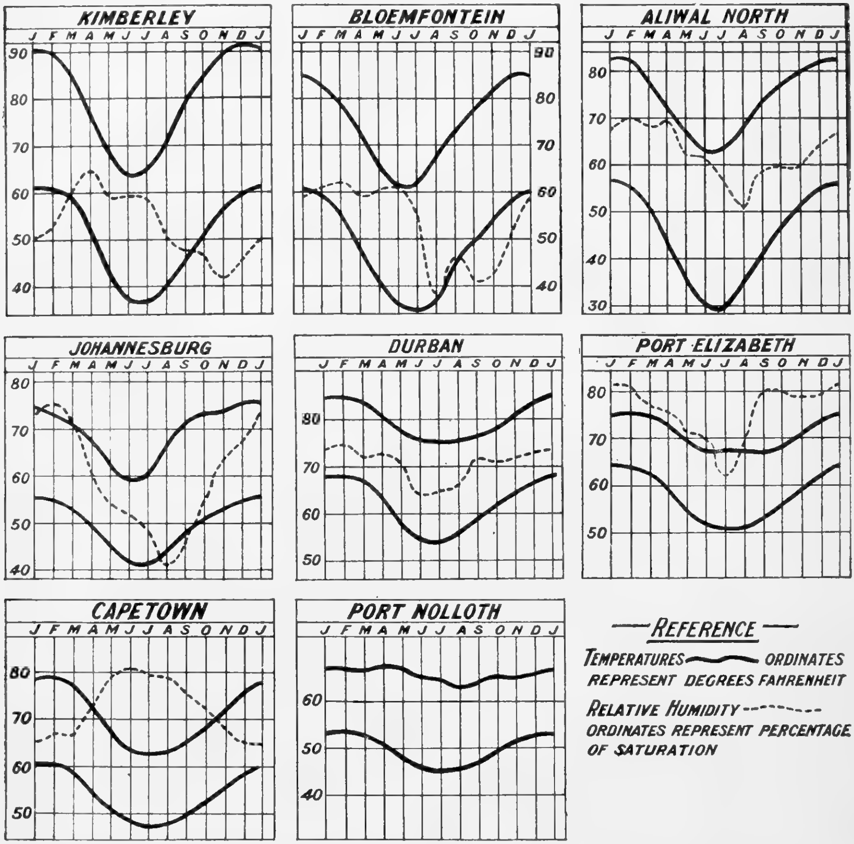
The average rainfall at Grahamstown is 28.79in. and at Maritzburg 35.79in.

sensitive by drought and dust. Climatic factors, therefore, seem to play a large part in making possible and aggravating the disease. To the climate, too, the preponderance of pepper trees in Bloemfontein and Kimberley is, I understand, to be attributed. When street-planting, on a large scale, was undertaken in these towns, this tree was one of the few known to grow well on the streets. In the other towns, several varieties of street tree grow well; there is therefore a smaller proportion of any one kind in the town.

It seems likely that the male pepper tree would cause hay fever to a serious extent in towns where the tree is very dense, and where the climate is very hot and dry during its principal flowering season. The degree of heat and dryness would probably need to be something approaching that of Bloemfontein and Kimberley during November and December. Such a climate during the flowering season of the pepper tree occurs over the southern and western part of the Free State, and over the bulk of the northern, central and western parts of the Cape Province.

In this area, male trees around isolated houses would also be expected to cause hay fever in susceptible occupants. The hay fever prevalent in Bethulie, Brandfort, and certain other small towns in this region, which have pepper trees, is probably due to this plant, though there has not been an opportunity of determining the varieties of pollen in the air of these towns. These small towns are very scattered, and it is probable that the density of

Chart (from Cox, 1922).
Mean Maximum Temperatures and Relative Humidity.



the pepper tree on a circular or square block of any considerable size in them would be very low. Such small scattered towns should be considered, not as a whole in this connection, but rather as groups of isolated houses with pepper trees around them.

There is evidence that the suffering of many Bloemfontein patients is largely due to a few pepper trees near to, and especially on the windy side of their residences. The benefit which some patients in Bloemfontein have derived from removing the pepper trees around their own erf, or from a change of residence to a house near which there were fewer or no pepper trees, also points to the same conclusion. This experience is in agreement with that recorded by Dr. Scheppegrell (*Scient. Americ.* Suppl. 1916), who found that hay fever caused by weeds was mainly due to plants in the immediate vicinity of the patient, and that the removal of these weeds gave great relief, although there was still some pollen in the air from weeds at a greater distance.

XIV. Prevention Recommended.

There is no satisfactory cure for hay fever; besides prevention is better. The removal of the male pepper tree, the plant that produces the toxic pollen, is recommended. It is fortunate that the cause of these epidemics is not a native plant occurring in large quantities in the veld, nor one which for any other reason it would be impracticable to remove.

An alternative is immunisation with a vaccine prepared from the pollen. But this would entail considerable inconvenience and expense to patients; would almost certainly mean an annual series of injections; and, even then, could not be relied upon to confer complete immunity. It would also be necessary, in the first instance, to arrange for the preparation of a vaccine, which would probably present some difficulty. According to Dr. Scheppegrell, extensive experience in America has shown that no method of dealing with hay fever, other than the removal of the pollen-producing plant, has given satisfactory results.

During the summer, the sex of the pepper tree can be recognised by the character of the flowers; and in winter by the fact that only the female tree bears "berries." The distinguishing character of the flowers of the male tree is the presence of golden yellow pollen in the anthers; whilst in the flowers of the female tree, the anthers are empty (sterile) and white in colour. In Bloemfontein the two sexes are about equal in number. It should be pointed out that, although the terms "male" and "female" have been used in describing the trees, this has been done as a matter of convenience and is not strictly accurate. Some male trees bear a few female flowers which, incidentally, form fruits.

Though experience has shown that several other varieties of street trees grow fairly well in Bloemfontein, attention has been given to the practicability of putting a female top on to the trunks of male pepper trees, and of obtaining, for planting out, young pepper trees which could be relied upon to bear only female flowers.

To replace male trees by small seedlings would be a gamble as far as the sex is concerned, as this cannot at present be recognised until the tree flowers. There is probably some trifling difference in the male and female seedlings by which the sex could be distinguished, even at a very early age, but a reliable character has not yet been observed. At present the only certain method of obtaining female trees from seedlings would be to delay planting out until the flowers appear.

Cuttings from a female plant would produce only female trees; hence experiments have been made to test the practicability of propagating the female tree from cuttings. Attempts have also been made to graft or bud a female top on to a male trunk, as well as to insert buds from a female plant on to seedlings. If practicable, this latter step would ensure that all seedlings would bear a female top. The experiments were performed at the College and also repeated independently by Mr. A.

Chisholm (who is in charge of the local Government Gardens) in conjunction with the Forestry Department; and by Mr. F. Griffiths, Superintendent of Parks. All gave negative results, except that Mr. Chisholm succeeded in the budding experiments in inducing buds to take, but found that the continued production of shoots from the stock, whether old or that of a seedling, gave so much trouble as to make the method valueless in practice. Regulated bottom heat was not available in any of the attempts to strike the cuttings.

XV. Dust.

Although more dust than pepper tree pollen was found on the pollen plates exposed in Bloemfontein, there is convincing evidence that dust is not the cause of the hay fever epidemics, in that, in some seasons, duststorms are frequent from July onwards, and yet it is only after the pepper tree comes into flower that hay fever commences. But it is probable that both the dustiness and dryness of the air of Bloemfontein predispose to and aggravate hay fever by making the mucous membranes more sensitive (Stuart-Low, 1919).

Dust is usually prevalent in Bloemfontein from August until the heavy summer rains begin. It is to be attributed to high winds at a season when the surface of the ground is bare, dry and powdery. The dusty winds at Bloemfontein are westerly. The worst duststorms are of the whirlwind type, in which the dust can be seen to be churned about, and whose onward march can be followed from long distances. As this kind of wind carries dust for many miles, preventive measures are impracticable. But duststorms of this type are fortunately rare. On most dusty days the wind probably blows more or less horizontally, and it can be noticed that much of the dust is carried only a short distance at one flight, to be dropped and picked up again by a succeeding gust. The chief sources of the dust carried into town by such winds are the bare veld (due to heavy grazing) and unmade tracks used by traffic at the sides of roads. Whether it is economically practicable to prevent this dust being carried into town could only be settled by trial (careful regulation of grazing on the town lands, tree planting, etc.). The evidence of enclosed and ungrazed, or lightly grazed areas, in and around Bloemfontein, shows that, despite a reduced rainfall in recent years, the climate is still capable of producing a sufficiently dense growth of vegetation to retain dust dropped into it from the wind. There are also fruitful sources of dust within the town itself.

XVI. Other Causes of Hay Fever in Bloemfontein.

There are many other causes of hay fever (pollinosis) and hay fever symptoms in and near Bloemfontein, in addition to the pollen of the pepper tree. The probable causes to which my attention has been called in the course of this investigation are: emanations from horses and cows (animal asthmas); eating grapes and melons (food idiosyncrasies); pollen of grass and certain weeds; pollen (or scent?) of various cultivated plants,

viz., lucerne, sunflower, Cosmos, sweet pea, Gypsophila, Acacia, scented Verbena, Hunnemannia; smell of carrots and raw potatoes; other odours, for example, naphthaline; changes in temperature; other changes in the weather; dust, smoke, stomach derangement, and bacteria. Except in the case of grass pollen, I have rarely found more than a single person suffering from any one of these presumed causes, so that their importance, even collectively, is small.

XVII. Dr. Ashe's Results.

Dr. E. Oliver Ashe, of Kimberley, tested the susceptibility of some Kimberley hay fever patients by scarification and rubbing in of pollen. Six individuals, not subject to hay fever, acted as controls, and none of them gave any reaction. Of ten who were subject to hay fever, six reacted to pepper tree pollen, and four did not. Of these four, one stated that she attributed her trouble to sunflowers, and testing similarly with sunflower pollen gave a violent reaction. The pollen to which the other three were sensitive was not determined. Dr. Ashe also arranged for experiments to be made in the De Beers Laboratory to test whether pepper tree pollen is wind-borne. Pepper tree pollen was found on the plates, but they were all exposed very near to pepper trees, the greatest distance from the nearest pepper tree being 50 feet. The report of Mr. J. C. Moran, who carried out the experiments, concludes: ". . . . when one considers the large number of pepper trees in Kimberley it follows as a reasonable supposition that there must be a considerable amount of pepper tree pollen in the air on those hot windy days in early summer when the pepper trees are in full bloom." I am indebted to Dr. Ashe for these results, which were communicated by letter.

It will be noticed that in Dr. Ashe's experiments, only 60 per cent. of the sufferers reacted to pepper tree pollen, whereas in the Bloemfontein scarification tests (Potts, 1921) all the hay fever patients reacted. I was investigating only what is here known as epidemic hay fever, and so tried to confine myself to typical epidemic patients. It is usually possible to recognise such sufferers by a few questions.

XVIII. Acknowledgments.

Valuable assistance in carrying out this investigation has been given by many persons both in Bloemfontein and elsewhere. Acknowledgment of some has already been made in the two previous articles, and in the text of the present communication. Much of the detailed work, especially that of examining the pollen plates, was done by Miss J. Raubenheimer (now Mrs. S. H. Pellissier) and Miss Helen Bergstedt, successive Demonstrators in Botany. The task of searching for pollen amongst the Bloemfontein dust was especially arduous, and demanded close and constant application. Miss Bergstedt also took charge of the work in 1921 during my absence on furlough.

Two senior students, Mr. C. J. C. Lemmer, and Mr. L. P. Spies have helped considerably, especially during the summer vacation of 1920-21, when there was a great pressure of work owing to the arrival of pollen plates exposed at other centres.

I am indebted to Mr. J. A. Caskie, City Engineer, Bloemfontein, for access to the evaporation records taken at Mazelspoort; and to Mr. C. Stewart, Chief Meteorologist, for the weather statistics, and especially for access to the Bloemfontein records.

Thanks are due to friends and officials at Kimberley, Grahamstown, Maritzburg, and Johannesburg, for exposing pollen plates and supplying information regarding the number of pepper trees. In this connection I should like especially to thank Mr. J. Hewitt, Director of the Albany Museum, Grahamstown, and Mr. Reginald W. H. Wisbey, then Science Master at the Kimberley Boys' High School.

I am indebted to the Government Printing and Stationery Office for the loan of the block to reproduce Figure 1 from Mr. Cox's article in a recent memoir of the Botanical Survey. The inoculation tests were again performed by Dr. S. M. de Kock; and the numerous tables have been prepared by Miss D. M. Gemmell, Demonstrator in Botany.

XIX. Summary.

Bloemfontein and Kimberley are subject to severe epidemics of hay fever in the early summer, especially in November and December. By the exposure of pollen plates, it was shown that the pollen of the pepper tree is virtually the only kind of pollen frequent in the air of Bloemfontein during the epidemics. Inoculation tests showed that hay fever patients reacted to pepper tree pollen; and this was the only kind of pollen found in the nasal discharge of epidemic patients. It is, therefore, concluded that the pepper tree is the cause of these epidemics, to which, indeed, they are popularly attributed. An account is given of the climate of Bloemfontein; and it is pointed out, that the pollen of this tree, which is normally sticky and carried by insects, becomes dry and powdery and is dispersed by the wind in the hot, dry weather prevalent in Bloemfontein during the epidemic season. Attention is called to many other ways in which the dry climate of Bloemfontein affects the epidemics. The difficulties in accepting the pepper tree as a cause of hay fever are dealt with. These are: the large size of its pollen; pollination by insects; and that the tree occurs in many towns of South Africa which are not troubled with hay fever. The explanations suggested are the hot, dry weather during the principal flowering season of the pepper tree; and the fact that this tree is cultivated in large numbers in Bloemfontein as a street and garden tree. Kimberley, whose climate is like that of Bloemfontein, and which, too, has many pepper trees, is also subject to these epidemics. To prevent the epidemics, the removal of the male pepper tree is recommended. Other causes of pollinosis and of hay fever symptoms in Bloemfontein are mentioned.

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THE MEASUREMENT OF THE HYDROGEN ION CONCENTRATION IN SOUTH AFRICAN SOILS IN RELATION TO PLANT DISTRIBUTION AND OTHER ECOLOGICAL PROBLEMS,

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Introduction.

The modern development of the ionic theory of solutions has given a much more definite meaning to the formerly somewhat vague terms "acid," "neutral" and "alkaline." The acidity of a solution is no longer defined according to a qualitative colour reaction with litmus or litmus paper, but is capable of exact quantitative expression in terms of the hydrogen ion concentration. The application of this definite measurement of the degree of acidity or alkalinity to the study of soil reaction, particularly in relation to the distribution of individual native plants and plant associations and to ecological problems generally, has recently been developed with very fruitful results by O. Arrhenius[4]* in Sweden and by E. T. Wherry[5, 6] in America, apparently independently. Salisbury[7] in England has also applied it to problems of plant succession particularly in woodlands. The present writers have only recently commenced a study of the acidity of South African soils from the modern standpoint, and the present paper is intended to illustrate some of the preliminary results obtained, and to indicate the particular problems on which such a study may be expected to throw considerable light. Since, however, the method has not, so far as we are aware, been previously described in South Africa, it seems advisable to discuss in greater detail the meaning of the terms used, and the method of their determination. The account here given is largely based upon the papers and books mentioned in the bibliography,[1, 2, 3, 6] and makes no claim to be in any way original. Quotations from these papers have been freely used and are acknowledged here, though not directly indicated in the text.

The Meaning of Acidity.

According to the modern ionic theory, many chemical compounds when in solution undergo an electrolytic dissociation into positively and negatively charged particles, known as ions. For example, when hydrochloric acid is dissolved in water, only a small proportion of it is present in solution as actual molecules of HCl, the greater portion being almost completely dissociated

* These numbers refer to the papers listed in the References at the end.

into positively charged hydrogen ions and negatively charged chlorine ions. Further, it has been clearly established that the characteristic properties of any acid solution, for example, sour taste, reddening of blue litmus, are entirely due to the presence in the solution of these hydrogen ions. Weak acids, that is, those whose acid properties are only slight, are only dissociated to a small extent and consequently there are few hydrogen ions present in their solutions. Strong acids, on the other hand, are almost entirely dissociated in solution, producing a high concentration of hydrogen ions. The strength of an acid solution is therefore dependent, not on the total quantity of acid present in it, but upon the number of hydrogen ions present in a certain volume of the solution, that is, on the hydrogen ion concentration. This is very well shown by Wherry[6] in connection with hydrochloric and formic acids. Normal solutions of these two acids each contain 1 gm. of acidic hydrogen per litre—the total quantity of acidic hydrogen is the same in each. The strong acid, however, is 75 per cent. ionised, while the weak acid is only 1 per cent. ionised. The hydrogen ion concentration of the former is therefore 0·75 gms. per litre, while that of the latter is only 0·01. The hydrochloric acid solution contains 75 times as many hydrogen ions as does the formic acid solution. "The situation," says Wherry, "is analogous to that of two men, both possessing £100, but one having £25 in a savings bank and £75 in his pocket, the other having £99 and £1 in these respective places. The first man can purchase 75 times the amount of any commodity that the second can, even though the total quantity of money they own is the same. Purchasing power, in this illustration, corresponds exactly to hydrogen ion concentration; for the amount of hydrogen which is ionised, not the total amount, determines most of the things an acid can do."

In the same way as acids depend for their properties on the presence of hydrogen ions, bases depend on the presence of hydroxyl ions, and the strength of a base depends on the number of hydroxyl ions present in a given volume of solution. A neutral solution is produced when the hydrogen ion concentration is equal to the hydroxyl ion concentration; acidity is due to a rise in the former, alkalinity to a rise in the latter.

Even pure distilled water is ionised to a slight extent and the water molecules dissociated into hydrogen and hydroxyl ions, these forming an equilibrium mixture, thus:—

$$H_2O \rightleftharpoons H^+ + OH^-$$

In such a mixture, according to the laws of mass action, the following relationship must hold. (Concentrations are expressed by means of square brackets).

$$\frac{[H^\cdot] \times [OH']}{[H_2O]} = \text{a constant.}$$

$$\therefore [H^\cdot] \times [OH'] = [H_2O] \times \text{a constant.}$$

Since the number of undissociated H_2O molecules in pure distilled water is relatively enormously large it can be taken as a constant and then

$$[H^{\cdot}] \times [OH'] = \text{a constant.}$$

This is known as the "water constant" K_w The numerical value of K_w has been determined by several methods, which need not be discussed here, and from these it is estimated that the value of K_w for one litre of pure distilled water at 18°C is $10^{-14 \cdot 14}$. Since in such water the hydrogen ion concentration must be equal to the hydroxyl ion concentration, for the water is neutral,

$$[H^{\cdot}] = [OH'] = 10^{-7 \cdot 07}$$

The concentrations of $H^{\cdot}$ and OH' present in pure water, although low, are thus quite definite. The concentration of H_2O molecules in solutions of ordinary concentration is practically unalterable by any alteration in the hydrolysis.

A consequence of the constancy of K_w is that all aqueous solutions contain both $H^{\cdot}$ and OH', and if one of these is known the other can be calculated, for example, if the hydrogen ion concentration of a solution is known to be 10^{-4}, then from the above

$$[H^{\cdot}] \times [OH'] = 10^{-14}$$
$$\therefore [OH'] = 10^{-10}$$

It is unnecessary therefore to state both the acidity and alkalinity of an acid or alkaline solution, but only its acidity or hydrion concentration.

Neutral solutions then are those in which, as in pure water,

$$[H^{\cdot}] = [OH'] = 10^{-7 \cdot 07} \text{ g. ions per litre.}$$

Acid solutions have a higher hydrion concentration than this, alkaline solutions a lower hydrion concentration.

The Expression of Hydrogen Ion Concentration.

Owing to the large variations possible in the hydrogen ion concentration—from 10^{0} to 10^{-14} gm. ions per litre—it becomes necessary to introduce a simplification, and this is done by determining the reciprocal of the logarithm of the hydrion concentration. An actual example will best illustrate this. If the hydrogen ion concentration of a solution is found to be 0·0000016 gm. ions per litre, then $[H^{\cdot}] = 1 \cdot 6 \times 10^{-6}$. Expressing this as a power of 10, we then get $[H^{\cdot}] = 10^{-5.8}$. It is thus possible to express the hydrogen ion concentration of any solution as a power of 10, and it is then simpler to omit the 10 and express the $[H^{\cdot}]$ by means of minus logarithms, which are merely the reciprocals of the logarithms of the hydrion concentrations, and are generally written $-\log [H^{\cdot}]$ or pH or P_H. The pH of the solution in the given example is, therefore, 5·8. Where this method of expressing the results is used the following points must be clearly borne in mind:

1. The value of pH for a neutral solution is 7·07.
2. Lower values of pH than this indicate an increased [H·] and therefore a greater degree of acidity; higher values indicate a greater degree of alkalinity.
3. If the pH is altered by one integer, the hydrogen ion concentration is altered 10 times, *e.g.*—

$$\text{pH7} = [\text{H}^\cdot]\ 10^{-7} \text{ and } \text{pH8} = [\text{H}^\cdot]\ 10^{-8}.$$

The hydrogen ion concentration of the second solution is ten times that of the first, though the difference between the pH values is only 1.

Where only a small range of acidity is likely to be encountered, it is frequently convenient to convert the pH into what is called "specific acidity" or "specific alkalinity." The specific acidity of a solution of pH = 7 is taken as unity, and this is altered 10 times whenever the pH is altered by one integer, *e.g.*, pH6 corresponds with a specific acidity of 10, pH5 a specific acidity of 100. For values of pH greater than 7, specific alkalinity is expressed as negative acidity, *e.g.*, pH8 corresponds with a specific acidity of −10, pH9 a specific acidity of −100. The specific acidity of any solution of given pH is then most easily obtained by plotting the known specific acidities against the integral pH values. From the curve thus obtained the specific acidity of any solution of known pH can be immediately read off.

An example of the usefulness of this method of expressing results is given by Wherry[6] as follows: "An *Arctostaphylos* association is recorded as having pH4·8 and a *Calluna* association pH4·6, but it is difficult to gain a conception of relative acidities represented by these figures. When translated into terms of the specific acidity, however, they yield 159 and 251 respectively, and it can then be seen at a glance that the *Calluna* soil is over 1½ times as acid as the *Arctostaphylos* soil." It should be pointed out, however, that where large variations in acidity are being dealt with, the pH form is the only convenient one for the graphical expression of results.

Buffer Action and the Effect of Dilution.

Dilute solutions of strong acids, such as hydrochloric acid, are readily affected by traces of alkali in the glass, ammonia from the air, etc. Similarly dilute solutions of strong alkalies are very sensitive to the carbon dioxide of the atmosphere. The hydrion concentration of such solutions is, therefore, very susceptible to change, and solutions of these substances of known pH cannot be prepared and kept for use. Salts of weak acids or weak bases, however, have a low hydrion concentration which is kept constant in the presence of acids or bases by the dissociation of a large reserve of electrolyte. In such solutions the hydrion concentration is only slightly affected by traces of acid or alkali, the large quantity of electrolyte acting as a "buffer" to small additions. An example of this buffer action is given by Evers and

Gamble[2] as follows:—"If we add one drop of hydrochloric acid to pure distilled water we probably change its pH by several integers, say from 7 to 3. If we add the same amount of acid to water containing a little sodium phosphate the change of pH will be very slight indeed." Salts of weak polybasic acids such as phosphates and borates exhibit strong buffer action, while salts of strong acids and bases show very slight buffer action. Buffer action is of the utmost importance in Nature and is exhibited to a marked degree by all physiological fluids. Its importance from our present standpoint, as will be seen when the method of determining pH is described, is that it enables us to prepare standard stock solutions of known pH, which are not affected by the traces of alkali in the glass vessels, of ammonia and of carbon dioxide in the atmosphere.

The effect of diluting a solution of a strong highly dissociated acid like hydrochloric acid is to cause a considerable change in the hydrion concentration. Dilution of weak, partially dissociated acids, however, causes very little change in pH. This will be more clearly understood by reference to the example already given of hydrochloric and formic acids. The former is 75 per cent. ionised even in a normal solution, consequently there is only 25 per cent. of reserve, undissociated electrolyte. Further dilution soon produces almost complete ionisation, and, after this, increasing dilution decreases the concentration of hydrogen ions in a given volume of solution, that is, it increases the pH. Formic acid, on the other hand, is only 1 per cent. ionised in a normal solution, which therefore contains 99 per cent. of reserve, undissociated electrolyte. Dilution of such a solution increases the dissociation, and consequently causes the production of more hydrogen ions, thus compensating for the increased volume of solution. This effect is seen in all buffer solutions. For example, a normal solution of asparagine has pH2·95, a tenth normal solution has pH2·97 and a hundredth normal solution pH3·11.

The Soil Solution.

Plants obtain food substances from the soil in solution in water, and the acid or alkaline reaction of the soil solution may, therefore, be expected to produce marked effects upon the vegetation growing upon any particular soil. The possibility of the reverse process—the vegetation itself producing changes in the soil reaction—must also be kept in mind. Soil acidity has in fact long been recognised as a factor of considerable importance to plant life, but the older methods of measuring it are all eminently unsatisfactory. The commonest method is by the use of litmus paper, which is a very defective indicator of acidity for several reasons, and often yields variable and contradictory results. Other titration methods measure the total quantity of acid substances present in the soil. Now the soil solution does not inherently differ from any other solution, and as we have seen the acidity of a solution depends, not on the total quantity of acid present, but upon the hydrogen ion concentration of the solution. The only satisfactory method, therefore, of measuring

soil acidity is by the determination of the hydrion concentration or pH of the soil solution. The hydrogen ions of the soil solution are probably not derived from any single substance or class of substances, but from a great variety of substances such as strong, highly-ionised inorganic acids, such as nitric, hydrochloric, and organic acids, such as oxalic acid, weak slightly-ionised inorganic acids, such as carbonic acid, and organic acids, such as acetic acid, salts of weak bases with strong acids, for example, ammonium oxalate, amino-acids, and the controversial "humic acids." There is still room for a great deal of work on the substances which produce soil acidity, but it should be clearly remembered that no matter what these substances are, their acidic effects are produced through the agency of hydrogen ions, and that the only satisfactory method of measuring the acidity is by the determination of the hydrion concentration.

One further point requires mention here. All soil solutions exhibit strong buffer action, probably owing to the presence of weak acids and of proteins and other such substances. As a consequence of this, the soil solution can be considerably diluted without producing a marked change in the pH value.

Method of Determining pH.

The most accurate method of measuring the hydrion concentration of a solution is an electrometric one depending on the use of the hydrogen electrode. This, however, involves the use of costly apparatus and is too complicated to be of real value in ecological studies; in any case it gives a much higher degree of accuracy than is really needed in such work. The second and more practicable method is a colorimetric one depending on the use of various indicators. These indicators exhibit characteristic colour changes corresponding with changes in the hydrion concentration of a solution. For instance, phenol red is yellow for all values of pH less than 6·5. For higher values it gradually changes through various shades of orange until at pH8 it becomes pink. Other indicators exhibit similar colour changes at different pH values, and it is possible to obtain a set of indicators showing definite colours over a whole series of pH values. Standard solutions of known pH can be prepared from substances which exhibit strong buffer action, and by choosing the standard solution which gives exactly the same shade of colour as the unknown solution with the same amount of indicator we can determine the pH with sufficient accuracy. Our first supply of the necessary indicators was obtained from the Veterinary Research Department, Onderstepoort, by courtesy of the Director, Sir Arnold Theiler, to whom and to Dr. H. H. Green our thanks are due.

The actual method of determining the soil acidity will now be described in greater detail. Stock solutions of standard acidity are prepared from sodium and potassium phosphates. A N/15 solution of disodium hydrogen phosphate, Na_2HPO_4 is obtained by dissolving 11·876 gms. of the salt in one litre of distilled water. This solution has a pH=9·18. A N/15 solution of potassium dihydrogen phosphate (pH=4·49) is obtained by dissolving 9·078 gms. of the salt in one litre of distilled water.

When these solutions are mixed in certain definite proportions, mixtures of known pH values between 4·49 and 9·18 are obtained, as will be seen from the accompanying table taken from Prideaux.[1]

No. of c.c. N/15 No_2 HPO_4.	c.c. N/15. KH_2 PO_4.	pH.
0	10	4·49
0·1	9·9	4·94
0·25	9·75	5·29
0·5	Etc.	5·59
1·0		5·91
2		6·24
3		6·47
4		6·64
5		6·81
6		6·98
7		7·17
8		7·38
9		7·73
9·5		8·04
9·75		8·34
9·9		8·68
10 0		9·18

From this table a graph can be constructed by plotting the pH values against the number of c.c. of N/15 Na_2HPO_4 in 10 c.c. of a mixture. From this graph it is possible to read off the composition of any mixture of given pH, and hence to prepare solutions of any desired pH.

A set of six indicators is used, each indicator showing a gradual colour change at different pH values. Thus bromthymol blue is yellow for values of pH below 6·5, between 6·5 and 7·5 it changes through various shades of green, until for higher values still it becomes blue. It can, therefore, be used to determine pH values 6·5—7·5. For more acid solutions three other indicators are used:—Bromcresol purple for values between 6·0 and 6·5, methyl red 4·5—6·0, and Bromphenol blue 3·5—4·5. For more alkaline solutions Phenol red indicates values between 7·0 and 8·5, and Cresolphthalein those between 8·5 and 10·0.

The soil extract is prepared by thoroughly mixing 10 gms. of soil with 50 c.c. of water. Tap water may be used provided its pH is not far removed from 7; in our experiments the pH of our tap water was determined as 7·2. The mixture is allowed to stand for about twelve hours, and the supernatant liquid is then poured off. In the actual determination of pH, 10 c.c. of this soil extract is taken and 10 drops of the indicator added. In the event of the extract being strongly coloured, it may be considerably diluted as already explained without appreciably altering the pH value. The extract is first tested with Bromthymol blue. Three possibilities then arise:

1. A yellow colouration may result. In this case the pH value is less than 6·5 and must be determined by the successive use of the three acid indicators named above.

2. A blue colouration may be given. The pH value is then greater than 7·5 and is determined by the successive use of the two alkaline indicators.

3. A green colour may be given. In this case the pH lies between 6·5 and 7·5. Mixtures of the stock solutions giving different pH values between 6·5 and 7·5 are then prepared, and 10 drops of indicator are added to 10 c.c. of each mixture, until a mixture is obtained which gives an exact colour match with the unknown solution. The pH of this mixture is known and hence the pH of the soil extract.

A similar procedure is followed with each of the other indicators and in this way the pH of any soil extract may be very exactly determined.

It should be noted that the indicators should be used in aqueous solution and not in alcoholic, since, according to Prideaux,[1] the addition of alcohol generally lessens the sensibility of an indicator, that is, the indicator requires a higher value of [H·] or [OH′] to bring about its colour change.

Work on South African Soils.

A considerable amount of work on South African soils has been done by Juritz,[13, 14, 15] Marchand,[16] Williams, Watt,[20] Hall,[17, 18, 19] and others. The latest bibliography will be found in the 1921 paper by the last-mentioned author.[18] Hall's work, while not primarily ecological, has constituted a notable advance in our knowledge of nitrification and lime requirements in numerous types of South African soils. He has shown that nitrification in South African soils, when compared with that in soils from many other countries, cannot be said to be exceptionally active, although it is good compared with the data from other areas. He agrees with Watt that nitrification in Transvaal soils is greater than at Rothamstead in England, but he points out that field data from Ithaca, N.Y., record very much superior amounts of nitric nitrogen than were found here, and he cannot endorse Watt's opinion that nitrification in Transvaal soils is, in general, superior to that in soils of most temperate climates.

In connection with the lime requirements of South African soils, one of Hall's tables dealing with 54 representative soils shows a variation from alkaline with 18·9 per cent. calcium carbonate to soils with a "veitch lime requirement" of 14,400 pounds per acre foot. The relatively high lime requirement of certain Natal High Veld soils agrees well with our preliminary results obtained by the pH colorimetric method, though it should be remembered that the lime requirement (a somewhat ill-defined term) is probably a measure of total acidity and not of real acidity.

Hydrogen Ion Concentration in South African Soils.

The results so far obtained by us are comparatively few in number and must be looked upon as merely preliminary. We

should like to lay emphasis once more on the fact that not only do the usually recognised characteristic properties of acids, such as taste, depend on hydrogen ion concentration, and not on the total quantity of acid present, but that it is extremely probable that the influence of acidity on vegetation depends in like manner on hydrogen ion concentration.

A. *Low Veld Soils.* (1) Various samples were tested first of all from virgin veld in the Scottsville neighbourhood of Pietermaritzburg near the Natal University College. A considerable amount of preliminary work was done with these samples in order to become familiar with the method.

Taking the results obtained from testing surface Low Veld soils in this neighbourhood we have found that these vary between pH6·0 and pH6·9. They are, therefore, to be classed as slightly acid soils (specific acidities +10 to very nearly 1). In this area shales occur near the surface and the soil is shallow. The veld has been considerably disturbed and the veld grasses are mostly primitive colonising species with a high proportion of ruderals.

(2) Our expectation had been that we should find the Scottsville soils either alkaline or at least neutral. We therefore proceeded to test a more typical sample of Low Veld soil taken from underneath a specimen of *Acacia benthami* thorn tree growing at Bisley. The pH value we found in this case to be 7·0. The soil, therefore, can be classed as neutral.

B. *High Veld Soils.* (1) Samples were next tested from the High Veld of the Zwartkop mountain. At altitudes of about 4,300 feet on the steep slopes we obtained samples which gave a very acid reaction, pH4·5—5·0. The specific acidity is therefore as high as 300, and the soil is as acid as typical *Calluna* soil in Europe. This somewhat surprising result at first made us inclined to doubt its reliability, but a further series of tests confirmed the result.

(2) Soil from the centre of the bush on the lower slopes of the Zwartkop gave pH7, or a neutral reaction, another unexpected result.

(3) Two samples from the Dargle (high veld) district at altitudes of about 4,500 feet were obtained. The first was from a slightly higher altitude, dry and somewhat clayey and gave an average reaction of pH5·7. The latter was a dark coloured moist soil and gave pH5·4. These results are very much less acid (specific acidity 30 ±) than those from Zwartkop. Both were from forest areas. It would appear that while High Veld soils are all acid, on the whole forest soils are not so acid as open grass veld soils, but the point requires much further testing.

(4) Samples from Signal Hill, near Maritzburg, were investigated with the object of determining the influence of aspect exposure. Samples from the slope facing north gave an average pH5·5, from the slope facing south, an average of 6·4. The north slope is open, grassy tree veld and is considerably more acid (nearly ten times) than the south slope, which is a forest area showing the earliest stages of forest succession. This bears out the idea that the complex of factors leading to the development

of close bush or forest type of plant community also results in a less acid type of soil in the High Veld.

Suggestions for Future Work.

The above results are put forward more with the object of making clear the possibilities of the method as applied to South African conditions than for the sake of the information they convey. Once the simple technique of the method is mastered, results are easily obtained. In its application to the general problems of plant ecology the following lines of research suggest themselves.

1. A comparative study of the main plant habitats in South Africa. We have chosen two of the main types in Natal (High Veld and Low Veld) as a starting point.

2. An application of the method to the study of plant succession, as has been done by Salisbury in England.[7] The reaction at different depths must be studied and definite figures can then be given for the degree of "leaching."

3. The study of individual plants and their distribution. The soils must be tested in which their roots are actually growing This has an obvious bearing on the important question of "plant indicators."

4. New light can probably be thrown on many important economic problems connected with (a) arboriculture, (b) general agriculture, (c) veld grazing and stock diseases. Styvesieckte (stiff sickness), *e.g.*, in cattle, which is becoming somewhat of a menace in certain parts of Natal, appears to be absent from Low Veld soils. Is its degree of prevalence possibly to be correlated with the degree of acidity in the High Veld soils?

Much information is already available regarding the degree of acid tolerance in various cultivated crops. A simple method of measuring accurately the degree of acidity in agricultural soils will enable the farmer to select the most suitable crops to grow. Altogether the method appears to be one of the most promising of all those applied to ecological and agricultural problems.

(5) Any study of the micro flora and fauna of the soil must be correlated with exact determinations of relative acidity or alkalinity. For example, while nitrifying bacteria are active even in acid soils, *Azotobacter* only occurs in neutral or alkaline soils.[8, 9] There is urgent need for investigations on these lines in South Africa.

6. The colorimetric method of measuring hydrogen ion concentration is not of course to be limited to soils. It can be and has been applied to various animal fluids and a big field is opened up in the possibility of its application to plant juices. Investigations of this nature are also at present in progress under our direction. A single example of the results obtained may be given here.

In the course of an autecological study of *Aloe saponaria* the cell sap was extracted, after freezing, from eight leaves, the sap from each leaf being kept separate. The oldest leaf, which was somewhat withered and showed signs of approaching death, gave

pH6·3. The one next to this gave pH5·8. All the others right to the youngest leaf gave pH5·5—5·6. The acidity of the cell sap appears therefore to remain remarkably constant throughout the life of the leaves, but shows a decrease as the end of the life period is reached. Probably this decrease is due to the withdrawal of organic acids from the dying leaf.

The determination of the hydrogen ion concentration of plant juices has been carried out by Truog and Meacham,[10] Clevenger,[11] and Haas,[12] whose papers (reviewed by E. J. Salisbury in *Journ. Ecol.*, VIII, 3, 1920) are cited in the accompanying bibliography.

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THE EFFECT OF SLOPE EXPOSURE UPON THE CLIMATE AND VEGETATION OF A HILL NEAR MARITZBURG: A PRELIMINARY INVESTIGATION.

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INTRODUCTION.

Ecological investigations on the vegetation of Natal, which have been in progress during the last ten or twelve years, have brought very clearly to light the existence of two main types of tree growth, differing conspicuously in their habitat, physiognomy, composition and succession. Of the two, Tree Veld, as it has been termed by Professor Bews,[4]* is one of the most extensive types of vegetation in South Africa. It has a characteristic, park-like appearance due to the growth of isolated clumps of trees and bushes in the surrounding grass land. The unique feature of this vegetation, as has often been emphasised, lies in the early stages of the succession, where invasion of the grass land is carried out by pioneers which are themselves trees. Once these are established, other trees and shrubs grow up in their shade, and large clumps may be formed. Naturally the constituents of such a formation are strong, light-demanding and xerophytic trees, the pioneers particularly being able to withstand intense sunlight, even in the early stages of their lives.

The second type of tree growth, generally spoken of as Bush or Close Bush, presents a decided contrast in appearance to the one just described. Instead of isolated, scattered clumps the trees grow close together, large areas being frequently covered with a dense canopy of trees and shrubs. In the deep shade cast by these, the undergrowth is naturally by no means luxuriant, though mosses, ferns and various Acanthaceae are fairly abundant. Around the margins of the bush, however, a dense, and at times almost impenetrable, growth of tall shrubs and climbers occurs. A study of the changes taking place around the margins of a spreading bush, and of those during the re-establishment of bush after fire, shows a very different type of succession from that characteristic of Tree Veld. The early stages are formed by the growth of tall, somewhat mesophytic grasses and shrubs, in the shade of which trees slowly establish themselves. As the growth

* The numbers refer to the papers listed in the References at the end of this memoir.

of the trees produces denser shade, the more light-demanding shrubs gradually disappear, and eventually are found only round the margins of the mature bush.[4] The succession is, in fact, exactly the reverse of that taking place in Tree Veld.

Close Bush is a much less extensive formation than is Tree Veld, its distribution being much more strictly limited by climatic conditions. Throughout Natal, and, indeed, throughout the eastern region generally, it is very noticeable that bush is confined to steep slopes facing towards the south-east. Tree Veld, on the other hand, occurs principally on flat ground or on slopes with a northern aspect, the actual type of Tree Veld probably being determined by edaphic factors. In a general way the reason for the localisation of bush on the south-eastern slopes is fairly clear. Such slopes are exposed to the rain-bearing winds from the Indian Ocean, and consequently receive a greater deposition of moisture in the form of rain and mist than do the northern ones. In addition, they are protected from the desiccating effects of the dry, hot winds that blow from the north at the end of the winter season.[2, 3] Even on the favourably exposed slopes, however, bush will not develop except in places with a fairly steep gradient, which permits of rapid cold air drainage, most of the constituent trees being unable to withstand frost.

Up to the present no precise quantitative data as to the differences in climatic conditions on slopes of different aspect have been obtained in Natal, though it is obviously of considerable interest to determine the exact conditions which have been responsible for the production of such profound divergences in the character of the vegetation. In other countries the influence of slope exposure on the distribution and successional changes of vegetation has attracted considerable attention, and the analysis of the contributory causes, particularly in America, has been the subject of much investigation. The effects of slope exposure in the Western States, for example, in such regions as the Rocky Mountains, Sierra Nevada and the Coast ranges, are stated to be very striking and definite.[5] Thus Ramaley (quoted by Harshberger[5]), writing of the plants of the mesas in Colorado, east of the Divide, states that:

"the vegetation on the north slopes of the mesas differs, more or less markedly, from that of the south slopes. The varying amount of moisture and sunshine are the important factors in determining this difference. The east and west ends of the mesas are also different in their plants. The west end being closer to the foothills is sheltered from the afternoon sun, while the east end is not thus protected. In spring, small streams from the melting snow on the hills water the west end of the mesa. The snow also lies lower there. Pine trees and quaking aspens grow there, while at the east end there are no trees at all.' "

In the Santa Catalina mountains of Arizona, Shreve (quoted by Harshberger[5]) has demonstrated that

"the direction of slope of a particular habitat is of prime importance in determining the precise character of its plant covering. The differences between the vegetation of a north facing and a south facing slope at the same altitude is roughly equal to the difference between two south facing slopes which are 1,000 vertical feet apart."[7]

The same author has also described this influence of slope in greater detail in " The Vegetation of a Desert Mountain Range as conditioned by Climatic Factors."[8] Robbins (quoted by Harshberger[5]), in outlining the native vegetation and climate of Colorado in their relation to agriculture, emphasises the fact that:

"'the intensity of sunlight is distinctly affected by exposure and also by degree of slope. If we assume the intensity of sunlight to be 100, when it strikes a surface at right angles, its intensity when striking that surface at an angle of 70° will be approximately 98·5, at an angle of 60° 96·5, and at an angle of 10° 33·4. In the lower mountain valleys of the north and central parts of Colorado the southern exposures support a semi-arid type of vegetation, composed of cedars, scattered yellow pines, yuccas, etc., while the cooler and moister northern exposures are frequently clothed with Douglas fir, aspen, Rocky Mountain maple, etc.' "[9]

From a study of the conditions in Eastern Pennsylvania Harshberger concludes

"that slope and exposure both have been fundamentally influential in producing divergences from an original, fairly uniform virgin soil and by interaction with the higher plants, animals and other soil organisms have produced profound differences in the animal and plant population of the two slopes."[5]

The Present Investigation.

The intention of the present paper is to give an account of a few results obtained in the course of a preliminary investigation into the precise differences in environmental conditions on northern and southern slopes in Natal. While admittedly giving a very incomplete idea of the total differences, they are presented with the view of illustrating the nature and interest of the results likely to be obtained by more extensive work and of the physiological and ecological problems likely to arise therefrom.

From what has already been said it is clear that the influence of slope exposure upon vegetation may be traced to: (1) The degree and duration of insolation; (2) the direction of the dry winds and of the rain-bearing winds; (3) differences in soil conditions depending partly on geological conditions, but largely the indirect result of climatic factors. As a result of differences in these factors, differences in other secondary factors, such as rate of evaporation, relative humidity of the atmosphere and air temperature will be established. These differences are probably responsible in the first instance for the marked differences in the character of the early stages of the succession on the two slopes. The vegetation itself then takes part in further modification of its environment, and differences in such factors as soil temperature and soil water content are probably due, partly to the climatic factors already mentioned, and partly to the influence of the covering vegetation. For example, the thick growth of tall shrubs in the early stages of bush must protect the underlying soil from the direct effects of insolation to a much greater degree than do the isolated pioneers of Tree Veld. All these factors take part in the still further modification of the subsequent stages of the succession, and eventually lead to the profound difference in the ultimate vegetation on the two slopes. The ultimate vegetation

itself may, then, still further modify the climatic conditions, for example, the presence of forest will increase the rainfall in its particular area.

The full effect of differences in the exposure to different winds with the resulting differences in rainfall, relative humidity and evaporation can only be gauged by a series of observations extending over at least a year, and the writer is endeavouring to obtain experimental plots for the purpose of such continuous investigation. The differences in sunlight intensity and other factors, which are at least partly correlated with it, may, however, be measured in the course of a single day. In fact, in the case of this particular factor, measurements throughout the day are of considerable interest, since the duration of high intensities is probably quite as important as the total insolation in its effect upon the vegetation.

For this preliminary work a typical hill—Signal Hill—was chosen on account of its proximity to Maritzburg. This is a low hill running east and west, that is, its slopes face north and south. The northern slope is covered with grass land in which the dominant grass is *Aristida junciformis*, which has largely replaced *Themeda triandra*. Scattered throughout the grass land are numerous clumps of trees and bushes principally composed of *Cussonia spicata*, *Combretum kraussii* and *Clerodendron glabrum*. Scrambling over the clumps are climbers such as *Rubus pinnatus*. *Smodingium argutum*, *Cissus cuneifolia* and others. The succession in these clumps has already been analysed and described by the writer in a previous communication to this Association.[1]

The southern side presents a decided contrast in appearance to the northern, but is less uniform in the character of its vegetation. On the less steep slopes and the flatter terraces the grass land closely resembles that on the northern slope, Aristida again being the dominant species. The characteristic clumps of the northern side are entirely absent, but on the steep slopes facing practically due south there occur unmistakably the early stages of bush formation. There is little reason to doubt that these slopes were at one time covered with dense bush which has been destroyed by fire and is only slowly regenerating. Recurring fires retard the succession, and will probably effectually prevent its ever progressing far beyond the early stages. Tall mesophytic grasses and shrubs (principally belonging to the Compositae, for example. Printzia spp.) form a dense covering of the slope, and scattered amongst these are a few young trees of *Cussonia spicata* and *Maesa rufescens*. Ferns also occur, such as *Mohria caffrorum* and *Pteris aquilina* (around the edges of the developing bush). though they are entirely absent from the northern slopes. When the trees of *Cussonia spicata* are more closely examined, they are found to have arisen as coppice shoots from the old stumps of large trees, which have been destroyed apparently by fire. In some cases quite young trees have been found springing from very large stumps, which are practically buried in the soil.

In this connection an interesting point may be mentioned. On the northern slopes the trees of *C. spicata* are being attacked and killed by white ants, and once a tree has fallen, it is very soon completely destroyed. On the southern slopes the trees are not attacked, and apparently even the broken stumps must be immune, seeing that they are still able to give rise to strong, vigorous coppice shoots, capable of growing into healthy young trees. Typical white ants' nests are absent from the southern slopes, and, while one cannot assume from this a complete absence of termites, the species on this side must be different from that on the other. Associated with the difference in vegetation, therefore, there is a difference in the animal population of the two slopes.

In order to determine some of the climatic differences, which are responsible for the production of such marked divergences in the character of the vegetal covering, it was decided to measure the following factors throughout the course of a single day:—

1. Sunlight intensity.
2. Rate of evaporation.
3. Air temperature.
4. Soil temperature.
5. Soil moisture content.

In addition, since *Cussonia spicata* occurs on both sides of the hill, the rate of transpiration of two trees, one on each side, was followed throughout the day.

Two stations were chosen, one on each side and as nearly as possible at the same height, though the one on the north side was somewhat lower than the other. That on the north side was in open grass land near a typical Cussonia clump. For the southern station a space was cleared—in order to remove the shading effect of the tall shrubs—near a tree of *Cussonia spicata* within the area of developing bush. At each station two of the senior students from the Natal University College were in charge of the observations, and I should like to take this opportunity of thanking these gentlemen for the willing assistance which they rendered in this connection.

Results.

1. *Sunlight Intensity.* This was measured by a chemical method depending on the amount of iodine set free in a mixture of potassium iodide and sulphuric acid in the presence of sunlight. This method has been successfully used by one of our students for the measurement of light intensity in various plant habitats, and will be described in detail in a subsequent paper. For the present it is sufficient to say that bottles containing similar quantities of the mixture were exposed for periods of one hour each, and the amount of iodine released was determined by titration. Results are given as mgms. of iodine set free per hour and are tabulated in the accompanying table.

It was unfortunate that the observations on the two slopes were not begun simultaneously, those on the southern slope being half-an-hour later than the others. A study of the table shows that the two slopes receive very similar intensities of sunlight throughout the morning up to about 11 a.m., the slightly greater readings on the southern slope probably being due to the difference in the time of the exposure. From 11 a.m. on, however, the northern slope receives a decidedly greater intensity of sunlight, and the difference becomes more and more pronounced

TABLE I.—SUNLIGHT INTENSITY.

A. NORTH SLOPE.		B. SOUTH SLOPE.	
Time of Exposure.	Intensity.	Time of Exposure.	Intensity.
7.30—8.35 a.m.	3·5	8.0—9.0 a.m.	4·0
8.35—9.35 a.m.	9·5	9.0—10.0 a.m.	11·5
9·35—10·35 a.m.	13·5	10.0—11.0 a.m.	14·5
10.35—11.35 a.m.	20·5	11.0—12.0 a.m.	20·5
11.35 a.m —12.35 p.m.	25·5	12·0—1·0 p.m.	22·5
12.40—1.40 p.m.	24·5	1·0—2·0 p.m.	18·5
1.40—2·40 p.m.	21·5	2·0—3.0 p.m.	7·5
2.40—3.40 p.m.	17·5	3.0—4.0 p.m.	5·0
3.40—4.40 p.m.	9·5	4.0—5.0 p.m.	3·0
4.40—5.40 p.m.	1·0	5.0—5.35 p.m.	0·3
Total	146·5	Total	107·3

throughout the afternoon, being particularly noticeable between 2 p.m. and 4 p.m. The difference in the total insolation received by the two slopes during the day is, of course, more marked at this season of the year, when the sun is north of the equator, but it must be remembered that this is also the dry season, and therefore a critical period for vegetation. The differences in such factors as sunlight intensity during the winter season are consequently of very great importance.

2. *Evaporation.* The rate of evaporation was measured by means of porous cup atmometers, mounted on burettes so that readings could be taken every hour.

The "evaporating power of the air" is greater on the northern slope throughout the day, and the difference becomes particularly pronounced during the afternoon from 2 p.m. onwards. On the southern slope the maximum evaporation occurred between 1 p.m. and 2 p.m., whereas on the northern slope the maximum was not reached until between 2 p.m. and 3 p.m. The difference between the rates of evaporation on the two sides was accentuated by a slight northerly breeze which sprang up about noon and from which the southern slope was sheltered.

TABLE II.—EVAPORATION.

A. NORTH SLOPE.		B. SOUTH SLOPE.	
Time.	Amount Evaporated n c.c.	Time.	Amount Evaporated in c.c.
8.0—8.35 a.m.	1·2	7.50—9.0 a.m.	1·8
8.35—9.35 a.m.	2·1	9.0—10.0 a.m.	1·6
9.35—10.35 a.m.	2·5	10.0—11.0 a.m.	1·6
10.35—11.35 a.m.	3·5	11.0 a.m.—12.0 noon	2·7
11.35 a.m.—12.35 p.m.	4·9	12.0—1.0 p.m.	2·4
12.35—1.35 p.m.	5·2	1.0—2.0 p.m.	3·5
1.35—2.35 p.m.	6·7	2.0—3.0 p.m.	3·0
2.35—3.35 p.m.	6·6	3.0—4.0 p.m.	2·9
3.35—4.35 p.m.	4·9	4.0—5.0 p.m.	2·0
4.35—5.35 p.m.	1·4	5.0—5.35 p.m.	0·4
Total	39·0	Total	21·9

3. *Air Temperature.* This was measured by ordinary mercury thermometers, a battery of three thermometers being used at each station. In the accompanying table the readings of each thermometer are recorded and also the average of the three.

TABLE III.—AIR TEMPERATURES.

NORTH SLOPE.					SOUTH SLOPE.				
Time.	No. 1	No. 2	No. 3	Average.	Time.	No. 1	No. 2	No. 3	Average.
7.30 a.m.	16·0	15·5	15·8	15·75±·25	8.15 a.m.	14·5	14·5	14·0	14·25±·25
8.30 a.m.	16·1	17·0	16·8	16·55±·45	9.0 a.m.	17·0	17·0	16·0	16·5 ±·5
9.30 a.m.	17·7	18·4	18·1	18·05±·35	10.0 a.m.	18·5	19·0	18·0	18·5 ±·5
10.30 a.m.	19·8	20·6	20·3	20·2 ±·4	11.0 a.m.	19·5	20·0	19·2	19·6 ±·4
11.30 a.m.	23·0	23·0	22·5	22·75±·25	12.0 noon	21·5	22·0	20·8	21·4 ±·6
12.30 p.m.	25·0	25·0	25·1	25·05±·05	1.0 p.m.	22·5	22·2	22·0	22·25±·25
1.30 p.m.	25·5	26·0	25·7	25·75±.25	2.0 p.m.	23	23·5	23·0	23·25±·25
2.30 p.m.	26·2	27·0	27	26·6 ±·4	3.0 p.m.	22	22.0	21·5	21·75±·25
3.30 p.m.	25·5	26·0	26	25·75±·25	4.0 p.m.	21	21·0	20·5	20·75±·25
4.30 p.m.	22·4	23·0	23	22·7 ±·3	5.0 p.m.	17	17·0	16·3	16·65±·35
5.30 p.m.	17·0	17·1	17·1	17·05±·05	5.35 p.m.	13·9	14·0	14·1	14·0 ±·1

The air temperature is therefore greater on the northern slope throughout the day, but the difference is a comparatively small one. The maximum temperature attained on the southern slope is 23·25°C., that on the northern 26·6°C., a difference of only 3·35°C. As in the case of the other factors measured, the difference reaches its maximum in the afternoon at about 3 p.m.

4. *Soil Temperature.* Three thermometers were inserted into the soil at each station to a depth of about 2 in. and were read at hourly intervals. The readings are given as in the case of the air temperatures.

TABLE IV.—SOIL TEMPERATURES.

NORTH SLOPE.					SOUTH SLOPE.				
Time.	No. 1	No. 2	No. 3	Average.	Time..	No. 1	No. 2	No. 3	Average.
7.30 a.m.	11·9	12·0	12·0	11·95±·05	8.15 a.m.	10·0	10·0	9·5	9·75±·25
8.30 a.m.	12·2	12·0	12·3	12·15±·15	9.0 a.m.	10·5	10·5	10·0	10·25±·25
9.30 a.m.	15·0	14·0	15·0	14·5 ±·5	10.0 a.m.	11·0	12·0	10·5	11·25±·75
10.30 a.m.	18·8	16·7	18·3	17·75±1·05	11.0 a.m.	11·7	12·2	11·2	11·7 ±·5
11.30 a.m.	22·9	19·3	21·6	21·1 ±1·8	12.0 noon	12·0	13·0	12·0	12·5 ±·5
12.30 p.m.	25·8	23·0	24·6	24·4 ±1·4	1 p.m.	12·6	13·5	12·5	12·75±·5
1.30 p.m.	26·4	24·0	25·0	25·2 ±1·2	2.0 p.m.	12·7	13·0	12·6	12·8 ±·2
2.30 p.m.	25·5	24·0	24·5	24·75±·75	3.0 p.m.	13·0	13·2	12·9	13·05±·15
3.30 p.m.	24·5	23·5	23·5	24·0 ±·5	4.0 p.m.	12·8	12·9	12·5	12·7 ±·2
4.30 p.m.	23·0	22·0	22·3	22·5 ±·5	5.0 p.m.	12·5	12·1	12·5	12·3 ±·2
5.30 p.m.	18·0	19·8	18·8	18·9 ±·9	5.35 p.m.	12·1	12·0	12·0	12·05±·05

The difference in the soil temperatures is perhaps more striking than in the case of any other factor, the maximum temperature on the northern slope (26·4°) being nearly double that on the southern slope (13·5°). The minimum temperatures recorded (11·9° and 9·5°), however, only differ by about 2·5°, so that the variation in soil temperature is much more extreme on the northern slope than on the southern. Apparently also the heating of the soil on the north side is very uneven, since the differences between the individual thermometers may amount to as much as 3·6°C.

5. *Soil Moisture Content.* A sample of the soil was taken at each station and brought into the laboratory, where the water content of a small portion of each sample was determined with the following results:—

North slope: Water content percentage of fresh wt. = 12·03%
South slope: do. = 25·43%

6. *Transpiration of* CUSSONIA SPICATA. This was measured by means of calcium chloride tubes attached to the leaves. The method is one which is being thoroughly investigated at the Natal University College, and will be described in detail later. It does not measure the actual transpiration, but rather the maximum transpiring power of the leaf over a given period. At each station three weighed tubes were attached to each tree, each tube being left on the tree for two hours. In the following table the increase in weight of each tube is given in mgms.:—

TABLE V.—TRANSPIRATION.

NORTH SLOPE.					SOUTH SLOPE.				
Time.	Increase in Weight.			Average.	Time.	Increase in Weight.			Average.
7.45—9.45	0·66	0·72	0·86	0·75±0·1	7.45—9.45	0·84	0·96	0·93	0·91±·06
9.45—11.45	1·06	1·14	1·10	1·10±0·04	9.45—11.45	1·33	1·45	1·38	1·39±·06
11.45—1.45	1·2	1·24	1·14	1·19±0·05	11.45—1.45	1·8	1·69	1·62	1·70±·09
1.45—3.45	0·76	0·88	0·90	0·85±0·07	1.45—3.45	1·1	1·12	0·98	1·07±·07
3.45—5.45	0·66	0·58	0·62	0·62±0·04	3.45—5.35	0·5	0·58	—	0·54±·04

In contrast with the other results tabulated, these are greater on the southern side than on the northern. This somewhat unexpected result is probably due to the fact already mentioned that the method does not measure the actual transpiration, but the maximum transpiring power of the leaf at the time. If this is so, the trees on the northern slope have a lower transpiring power, *i.e.*, a greater power of resisting water loss, than do those on the southern slope.

Summary and Conclusions.

In the accompanying figure (p. 216) the series of observations recorded in the foregoing tables are presented in graphical form. The curves thus obtained show very clearly what has already been repeatedly emphasised, that the differences between the two slopes are comparatively slight during the morning, but become very pronounced from noon onwards. Thus the curves for sunlight intensity are very similar up to 11 a.m., after which they begin to diverge, until at 2 p.m. they are widely separated. A very noticeable feature of these curves is the sudden decrease in the sunlight intensity on the southern slope after 2 p.m., the intensity between 2 p.m. and 3 p.m. being even less than that on the northern slope between 3.30 p.m. and 4.30 p.m.

Both air temperature and rate of evaporation continue to increase after the sunlight intensity has reached its maximum, and the curves for these two factors appear to follow one another fairly closely, air temperature and rate of evaporation on each side reaching a maximum at about the same time. The soil temperature curves show striking divergences, that for the south slope showing little rise and fall and reaching a maximum at about 3 p.m., while that for the north slope rises steeply until 1.30 p.m., then falls slowly until 4.30 p.m., after which a more rapid fall begins.

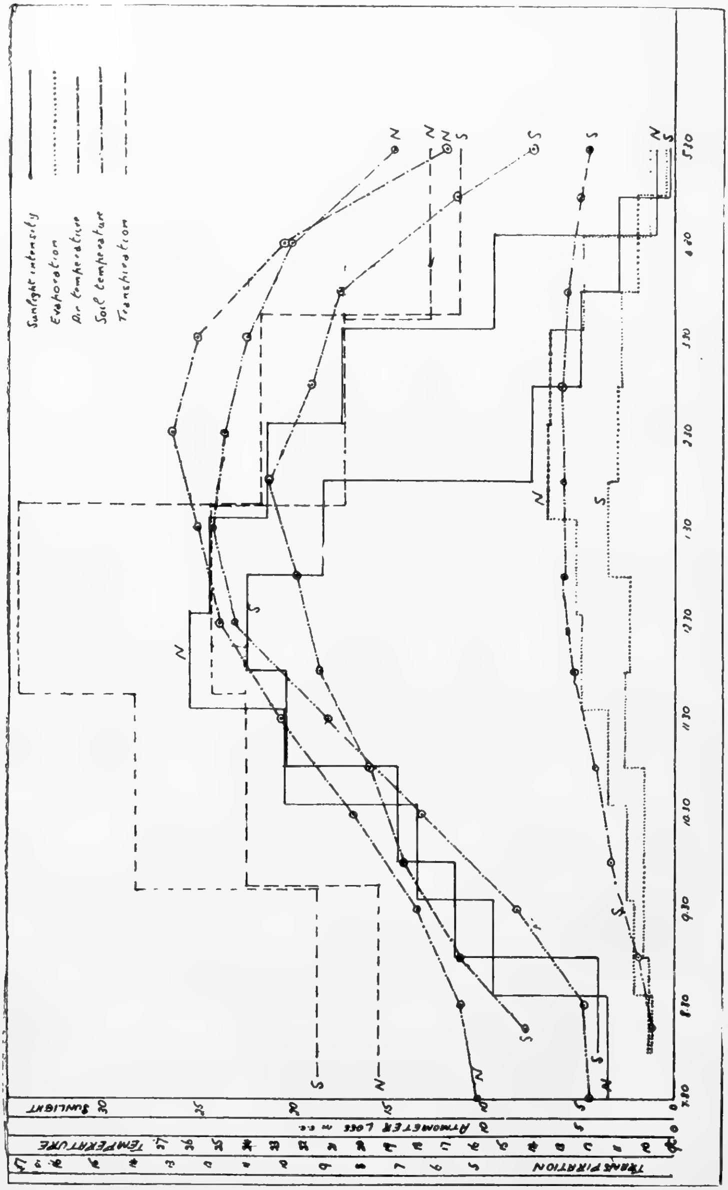
The transpiration curves are interesting in that they appear to follow the curves for sunlight intensity more closely than those for air temperature or evaporation. This is particularly shown by the curve for the southern slope, which shows a large decrease in the period from 1.45 p.m. to 3.45 p.m. corresponding with the similar decrease in sunlight which occurs after 2 p.m. This suggests that the variations in the transpiring power are principally due to stomatal movements which are closely correlated with variations in the light intensity, but the matter is one which requires further investigation.

The results of this preliminary investigation may be briefly summarised as follows:—

1. Marked differences exist in the character of the vegetation on the northern and southern slopes of Signal Hill.

2. These differences are probably principally due to differences in the climatic conditions on the two sides of the hill and partly to differences in the soil conditions.

3. Even in the course of a single day the two slopes show marked differences in such environmental factors as sunlight intensity, air temperature, rate of evaporation and soil temperature.



4. The soil on the southern slope is considerably moister than that on the northern.

5. Trees of *Cussonia spicata* appear to have a greater transpiring power on the southern slope than on the northern, *i.e.*, the trees on the northern slope have a greater power of resisting water loss.

Eventually it is hoped to obtain a more complete idea of the differences on the two sides of the hill by means of whole-day investigations, similar to those described above, at various seasons of the year, and also by continuous weekly observations extending over at least a year.

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THE COMPOSITION OF SOME INDIGENOUS GRASSES.

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INTRODUCTION.

A considerable number of analyses of South African grasses have already been recorded, but so far there has been but little systematic work done in this direction. Marchand[1] * deplores the lack of investigation into our native fodder plants, remarking that " in most cases the composition of our native plants is represented by the analysis of a single sample." There are so many factors--state of maturity, habitat, weather conditions—that affect the composition and feeding value that a single analysis must be regarded merely as pioneer work, as an indication of the approximate composition of the plant, although, of course, the single analysis is true for that particular sample.

Dr. Bews,[2] in his " Grasses and Grasslands of South Africa," remarks: " Chemical analyses, therefore, to be of value, should be repeated at intervals throughout the season, and this, so far as I am aware, has seldom been done."

Some of the earliest investigations into the composition of grasses of South Africa are those of Juritz[3] and Ingle,[4, 5] which have been continued by the former, and by Vipond[6] and Marchand.[1] Sawer[7] in the Cedara Memoirs gives some " Notes on the Botanical and Chemical Composition of the Veld Herbage of Natal," dealing mainly with the veld of Cedara and its neighbourhood. Here again the composition of the grasses noted is based on a single analysis only. This work was continued to some extent in later years, but no results were published. During the period of the war the investigation lapsed until it was again taken up by the writer in the Cedara laboratory early in 1920.

COLLECTION OF SAMPLES.

Samples of the grasses most commonly occuring on the veld of Cedara Experiment Farm were collected during the years 1920-1922 at approximately the same period of each year, and from areas of similar soil type, except, of course, in the case of vlei species. At the outset some difficulty was experienced in obtaining samples at a stage of growth as nearly as possible the same. Ultimately it was decided to collect early in the flowering period, whilst anthers were showing, but before the seed had

* These numbers refer to the papers listed in the References.

set. In order to minimise variations due to weather conditions, samples were collected on bright, sunny days, but not during any period of prolonged dry weather. In succeeding years samples were taken from approximately the same locality as in the case of the first sample. Thus the majority of grasses are represented by three analyses, or two only in the case of the early flowering species.

During the year 1921-1922 the scope of the work was enlarged and samples of certain species were collected at monthly intervals, as far as possible at the same stage of growth, so as to study the seasonal variations of the same species.

Methods of Analysis.

The official methods as used in the Department of Agriculture for the analysis of feeding stuffs were employed in this investigation, with the addition that true proteins were also determined. "Crude protein" is arrived at simply by taking the figures for total nitrogen and multiplying by 6·25, assuming that all proteins contain 16 per cent. of nitrogen. In grasses and similar immature herbage all the nitrogen is not present as protein, but a variable proportion is accounted for by ammonium compounds and amides, which contain varying amounts of nitrogen, and whose feeding value differs greatly from that of protein. For the determination of true protein the method of Barnstein[8] was employed. Briefly, this method is as follows: 2 grammes of the sample are boiled with 50 c.c. of water, 25 c.c of copper sulphate solution (60g. per litre) added, and then 25 c.c. of a 1·25 per cent. solution of sodium hydrate, with constant stirring. After settling, the supernatant fluid is decanted through a filter and the residue washed by decantation, and finally on the filter. The nitrogen content of the residue is determined as usual, multiplied by 6·25, and taken as true protein. This is, of course, a conventional method, but it gives results that are comparable, especially when dealing with a similar class of feeding stuff, and enables a better estimate of the feeding value to be made than if crude protein alone were considered.

The difference between the total nitrogen and that found by Barnstein's method is the non-protein nitrogen, and as most of it is present as amides it is usually so expressed in the results of analysis. Asparagin being taken as a typical commonly occurring amide, the non-protein nitrogen is calculated to this compound by multiplying by $\frac{33}{7}$.

The term "amide" is unfortunate, as it covers so great a diversity of compounds, but it has been established by custom. Armsby[9] suggests the use of the term "non-protein" as being preferable.

The nutritive ratio is calculated from the following formula:

Crude fat $\times$ 2·3 + soluble carbohydrates + amides $\times$ 0·5.

True Protein.

Any relative values assigned to the grasses investigated should be based on their digestible constituents. Here, however, the writer was faced with the difficulty that there are no experimental data on the digestibility of South African grasses. Henry and Morrison[10] gives a very valuable compilation of American analyses of feeding stuffs and results of digestion experiments, and on this basis have calculated the percentage of digestible nutrients in a great variety of feeding stuffs. It would be feasible to use their factors for average grasses, and so calculate approximate figures for the digestible nutrients in them, but this would not appreciably affect the relative feeding values calculated for the grasses under consideration, and so would not repay the extra calculations required. Hence the calorific value based on the total percentages has been taken as the basis of comparison. For the heats of combustion of the three chief classes of food the figures of Rubner[11] have been used.

1 gram of fat yields 9,300 calories.

1 gram of protein yields 4,100 calories.

1 gram of carbohydrate yields 4,100 calories.

The crude fat or ether extract, containing ether-soluble matter of less calorific value than pure fat is probably overrated by using these figures. In accordance with the usage of Henry and Morrison and other writers, the crude protein has been used in the calculation instead of pure protein. Armsby[12] considers that for maintenance non-protein may be of equal value to true protein. Later investigators (Atwater[13]) give a higher value for protein (4,400), but as the value of asparagine is given by Ingle[5] as 3,500 calories, the ultimate result does not differ very materially from the figures used. Crude fibre has been neglected in calculating the calorific value, although it does certainly have some value.

Finally, all results have been calculated on the absolutely dry material, thus giving a basis for comparison. The average air-dried sample contained about 11 per cent. of moisture. It may be added that all analyses were made in duplicate, and in cases when agreement of results was not as close as was desired the analyses were repeated to ensure a fair average.

Classification and Relative Values.

Table I gives the average analyses of the grasses under review, the number of samples of each species dealt with being shown in the third column. In the second column an attempt has been made to allocate the species to four main groups:—

R. Ruderal: Such species as *Eleusine indica*, *Panicum proliferum*, which are commonly found on waste lands.

Veld: Average climax veld species—for example, *Anthistiria imberbis.*

TABLE I.

PERCENTAGE COMPOSITION OF INDIGENOUS GRASSES: AVERAGE OF ANALYSES.

Results are all calculated on the absolutely dry sample.

NAME	Type	Number of Analyses	Ash	Phosphoric Oxide	Crude Fat	Crude Fibre	Crude Protein	True Protein	Amides, etc.	Soluble Carbohydrates	Calorific Value	Nutritive Ratio
Andropogon amplectens ..	Veld	1	5·80	—	2·06	37·50	3·71	3·35	0·28	51·01	2435	1:16·7
,, ceresiaeformis ..	Veld	3	5·02	0·17	2·56	35·83	4·35	3·94	0·31	52·34	2562	1:14·8
,, hirtus ..	P	2	5·27	0·21	2·22	41·20	5·08	4·48	0·45	46·38	2316	1:12·6
,, nardus ..	P	3	6·32	0·23	3·09	38·06	5·46	4·56	0·68	47·29	2450	1:12·3
,, schirensis, var. angustifolia ..	Veld	3	6·39	0·21	2·24	36·87	4·21	3·86	0·26	50·38	2446	1:14·5
Anthistiria imberbis ..	Veld	5	6·64	0·21	2·77	35·40	5·87	5·23	0·49	49·47	2527	1:10·8
Aristida junciformis ..	P	3	4·38	0·16	1·64	41·24	5·25	4·66	0·45	47·63	2321	1:11·2
Axonopus semialatus, var. ecklonii ..	Veld	2	7·70	0·23	2·70	36·10	10·31	8·81	1·12	43·57	2460	1: 5·7
Cynodon dactylon ..	R	3	11·00	0·40	2·40	28·53	15·28	11·88	2·57	43·62	2639	1: 4·3
Cyperus esculentus ..	Veld	2	8·26	0·34	2·49	25·06	9·70	8·63	0·81	54·75	2874	1: 7·1
Digitaria diagonalis	Veld	3	5·65	0·16	1·89	42·40	3·91	3·38	0·40	46·28	2233	1:15·1
,, horizontalis ..	R	3	7·10	0·34	3·11	31·90	8·72	7·40	1·00	49·49	2676	1: 7·8
,, sanguinalis ..	R	5	10·74	0·59	2·84	28·60	15·27	12·07	2·41	43·34	2667	1: 4·3
,, sanguinalis (luxuriant growth) ..	R	1	7·48	—	2·55	33·37	9·20	7·66	1·16	47·78	2573	1: 7·1
,, tricholaenoides ..	Veld	2	7·07	0·21	2·74	37·88	7·92	6·48	1·08	44·75	2414	1: 8·0
Eleusine indica ..	R	5	7·56	0·34	2·26	31·90	12·92	9·51	2·57	46·20	2634	1: 5·6
Eragrostis brizoides ..	Veld	2	5·25	0·20	2·48	37·37	7·47	6·01	1·10	47·79	2496	1: 9·2
,, chalcantha ..	Veld	2	5·82	0·21	2·23	35·92	6·76	5·70	0·80	49·53	2515	1:10·0
,, chloromelas ..	P	3	5·53	0·21	2·23	38·99	9·75	7·46	1·72	44·07	2414	1: 6·7
,, curvula ..	P	2	4·64	0·20	1·96	42·46	8·17	5·73	1·84	43·37	2296	1: 8·5
,, plana ..	P	3	5·50	0·27	1·87	38·62	8·42	6·26	1·63	46·12	2410	1: 8·2
Harpechloa capensis ..	Veld	2	6·01	0·22	2·38	37·10	8·53	7·17	1·03	46·31	2470	1: 7·5
Leersia hexandra ..	Vlei	2	14·67	0·48	2·63	32·12	10·46	9·49	0·73	40·36	2328	1: 5·8
Microchloa caffra ..	Veld	1	5·71	—	2·46	34·41	6·77	5·94	0·63	50·85	2591	1: 9·6
Panicum ecklonii ..	Veld	1	8·56	—	2·42	33·41	9·19	8·18	0·76	46·67	2515	1: 6·4
,, laevifolium ..	R	5	8·45	0·28	1·92	35·22	9·21	6·55	2·00	45·86	2436	1: 7·9
,, proliferum ..	R	4	8·29	0·31	2·14	31·38	13·16	8·96	3·17	46·06	2627	1: 5·9
,, serratum ..	Veld	2	9·34	0·29	2·28	35·95	9·15	6·82	1·76	43·85	2385	1: 7·3
Rottboellia compressa, var. fasciculata:												
from Vlei ..	Vlei	6	4·98	0·29	1·58	36·44	3·54	3·02	0·39	53·59	2489	1:19·5
from Experiment Plots ..	Vlei	2	4·98	0·22	1·74	35·20	6·09	5·02	0·81	52·25	2554	1: 7·5
Setaria imberbis ..	R	5	8·93	0·38	2·29	33·15	9·18	7·00	1·64	46·99	2516	1:11·8
Sporobolus indicus ..	P	3	6·89	0·24	1·79	38·11	7·74	6·16	1·19	45·86	2364	1: 8·5
Trachypogon polymorphus ..	P	2	3·77	0·13	1·42	43·44	3·23	2·73	0·37	48·27	2243	1:19·0
Tricholaena rosea ..	Veld	3	6·63	0·25	1·86	38·17	8·88	6·15	2·06	45·13	2387	1: 8·2
Tristachya leucothrix ..	Veld	2	6·07	0·23	2·22	37·13	8·41	7·21	0·90	46·47	2457	1: 7·3
Kikuyu ..		4	11·28	0·57	2·80	26·42	18·34	12·21	4·63	42·65	2761	1: 4·2
Veld Hay, 1914 ..		7	5·98	—	2·62	35·20	4·51	4·06	0·34	51·80	2552	1:14·3
Veld Hay, 1915 ..		10	5·97	—	3·03	33·65	3·74	3·29	0·34	53·73	2638	1:18·5

NOTES TO TABLE I.

1. Calorific Value. The value in calories of 1g. of the dry sample is given here.

2. Cyperus esculentus, whilst not belonging to the order Gramineae, has been included on account of its abundance and the readiness with which it is consumed by stock. It is popularly known as Watergrass.

3. The analyses, carried out in the Cedara Laboratory, of Kikuyu Grass and of Veld Hay are included for the purpose of comparison with the species investigated. The samples of Veld Hay were taken in duplicate at fortnightly intervals, and were at a stage of growth rather more advanced than in the case of the samples collected by the writer.

P.: Coarse pioneer species—for example, *Aristida junciformis*, *Eragrostis curvula*, also post-climax species—for example, *Andropogon nardus*. These coarse grasses have been included in the investigation more for the purpose of comparison with other types than for their actual feeding value, although in their young stages they are eaten by stock.

Vlei: Species growing in wet vlei lands—for example, *Rottboellia compressa*.

In Tables II and III is given the classification of the various species according to their relative values based on:—

(a) Crude fibre.
(b) Calorific value.
(c) Crude protein.
(d) True protein.

This brings out clearly, especially with regard to crude fibre and calorific value, the fact that the feeding value of the ruderal species is decidedly higher than that of the average veld species, whilst the coarse pioneer and post-climax grasses fall considerably below the second type. This is as might be expected, for the conditions of cultivated lands favour a more succulent herbage which would utterly fail in competition with other grasses in the open veld. This point is further dealt with in a later section.

In regard to the percentages of protein—both crude and true, for the order differs but little in these two cases—this distinction is present, but is not so marked as in the case of crude fibre and calorific value.

By all these methods of classification amongst the first half-dozen species in order of merit are found *Cynodon dactylon*, *Digitaria sanguinalis*, *Panicum proliferum*, and *Eleusine indica*, whilst *P. laevifolium* and *Setaria imberbis* are not far behind.

Of more importance to the farmer are the ordinary veld species. Here the most striking feature, at first glance, is the similarity of composition of this type. First take the order under the heading of crude fibre. Here the species with the lowest amount of fibre is *Panicum echlonii* with 33·4 per cent., and the highest is *Tricholaena rosea* with 38·2 per cent., a range of less than 5 per cent. variation. Still closer come the majority of this type; ten out of the total of fourteen species come within a variation of 2 per cent., ranging from *Anthistiria imberbis* with 35·4 per cent. to *Eragostis brizoides* with 37·4 per cent., and these include the grasses of most importance to the farmer.

Similarly, the calorific value of this type ranges from *Microchloa caffra* with 2,591 calories to *Panicum serratum* with 2,385 calories. Again taking the majority of the species, we find that ten out of fourteen show a range of just over 100 calories, the highest being *Anthistiria imberbis* (2,527 calories), and the lowest *Digitaria tricholaenoides* (2,414 calories), thus again showing a fairly close agreement.

Table II.

Classification of Grasses According to Percentages of Crude Fibre and Calorific Value.

Crude Fibre.			Calorific Value.		
Position.	NAME.	%	Position.	NAME.	Fuel Value
					Calories.
1	Cyperus esculentus	25·1	1	Cyperus esculentus	2874
1	Cynodon dactylon	28·5	2	Digitaria horizontalis	2676
3	Digitaria sanguinalis	28·6	3	Digitaria sanguinalis	2667
4	Panicum proliferum	31·4	4	Cynodon dactylon	2639
5	Digitaria horizontalis	31·9	5	Eleusine indica	2634
6	Eleusine indica	31·9	6	Panicum proliferum	2627
7	Leersia hexandra	32·1	7	Microchloa caffra	2591
8	Setaria imberbis	33·1	8	Digitaria sanguinalis *	2573
9	Digitaria sanguinalis *	33·4	9	Andropogon ceresiæformis	2562
10	Panicum ecklonii	33·4	10	Rottboellia compressa (Exp. Plots)	2554
11	Microchloa caffra	34·4	11	Anthistiria imberbis	2527
12	Rottboellia compressa (Exp. Plots)	35·2	12	Setaria imberbis	2516
13	Panicum laevifolium	35·2	13	Panicum ecklonii	2515
14	Anthistiria imberbis	35·4	14	Eragrostis chalcantha	2515
15	Andropogon ceresiaeformis	35·8	15	Eragrostia brizoides	2496
16	Eragrostis chalcantha	35·9	16	Rottboellia compressa (Vlei)	2489
17	Panicum serratum	36·0	17	Harpechloa capensis	2470
18	Axonopus semialatus	36·1	18	Axonopus semialatus	2460
19	Rottboellia compressa (Vlei)	36·4	19	Tristachya leucothrix	2457
20	Andropogon schirensis	36·9	20	Andropogon nardus	2450
21	Harpechloa capensis	37·1	21	Andropogon schirensis	2446
22	Tristachya leucothrix	37·1	22	Panicum lævifolium	2436
23	Eragrostis brizoides	37·4	23	Andropogon amplectens	2435
24	Andropogon amplectens	37·5	24	Digitaria tricholænoides	2414
25	Digitaria tricholaenoides	37·9	25	Eragrostis chloromelas	2414
26	Andropogon nardus	38·1	26	Eragrostis plana	2410
27	Sporobolus indicus	38·1	27	Tricholæna rosea	2387
28	Tricholaena rosea	38·2	28	Panicum serratum	2385
29	Eragrostis plana	38·6	29	Sporobolus indicus	2364
30	Eragrostis chloromelas	39·0	30	Leersia hexandra	2328
31	Andropogon hirtus	41·2	31	Aristida junciformis	2321
32	Aristida junciformis	41·2	32	Andropogon hirtus	2316
33	Digitaria diagonalis	42·4	33	Eragrostis curvula	2296
34	Eragrostis curvula	42·5	34	Trachypogon polymorphus	2243
35	Trachypogon polymorphus	43·4	35	Digitaria diagonalis	2233

* A sample of unusually luxuriant growth.

TABLE III.

CLASSIFICATION OF GRASSES ACCORDING TO PERCENTAGES OF PROTEIN.

Crude Protein.			True Protein.		
Position.	NAME.	%	Position.	NAME.	%
1	Cynodon dactylon	15·3	1	Digitaria sanguinalis	12·1
2	Digitaria sanguinalis	15·3	2	Cynodon dactylon	11·9
3	Panicum proliferum	13·2	3	Eleusine indica	9·5
4	Eleusine indica	12·9	4	Leersia hexandra	9·5
5	Leersia hexandra	10·4	5	Panicum proliferum	9·0
6	Axonopus semialatus	10·3	6	Axonopus semialatus	8·8
7	Eragrostis chloromelas	9·8	7	Cyperus esculentus	8·6
8	Cyperus esculentus	9·7	8	Panicum ecklonii	8·2
9	Digitaria sanguinalis *	9·2	9	Digitaria sanguinalis *	7·7
10	Panicum lævifolium	9·2	10	Eragrostis chloromelas	7·5
11	Panicum ecklonii	9·2	11	Digitaria horizontalis	7·4
12	Setaria imberbis	9·2	12	Harpechloa capensis	7·2
13	Panicum serratum	9·1	13	Tristachya leucothrix	7·2
14	Tricholæna rosea	8·9	14	Setaria imberbis	7·0
15	Digitaria horizontalis	8·7	15	Panicum serratum	6·8
16	Harpechloa carpensis	8·5	16	Panicum laevifolium	6·6
17	Eragrostis plana	8·4	17	Digitaria tricholaenoides	6·5
18	Tristachya leucothrix	8·4	18	Eragrostis plana	6·3
19	Eragrostis curvula	8·2	19	Sporobolus indicus	6·2
20	Digitaria tricholænoides	7·9	20	Tricholaena rosea	6·2
21	Sporbolus indicus	7·7	21	Eragrostis brizoides	6·0
22	Eragrostis brizoides	7·5	22	Microchloa caffra	5·9
23	Microchloa caffra	6·8	23	Eragrostis chalcantha	5·7
24	Eragrostis chalcantha	6·8	24	Eragrostis curvula	5·7
25	Rottboellia compressa (Exper. Plots)	6·1	25	Anthistiria imberbis	5·2
26	Anthistiria imberbis	5·9	26	Rottboellia compressa (Exper. Plots.)	5·0
27	Andropogon nardus	5·5	27	Aristida junciformis	4·7
28	Aristida junciformis	5·2	28	Andropogon nardus	4·6
29	Andropogon hirtus	5·1	29	Andropogon hirtus	4·5
30	Andropogon ceresiæformis	4·4	30	Andropogon ceresiaeformis	3·9
31	Andropogon schirensis	4·2	31	Andropogon schirensis	3·9
32	Digitaria diagonalis	3·9	32	Digitaria diagonalis	3·4
33	Andropogon amplectens	3·7	33	Andropogon amplectens	3·4
34	Rottboellia compressa (Vlei)	3·5	34	Rottboellia compressa (Vlei)	3·0
35	Trachypogon polymorphus	3·2	35	Trachypogon polymorphus	2·7

* A sample of unusually luxuriant growth.

On examining the relative values in protein content this similarity of composition, whilst not so evident, may be still observed. The highest crude protein content is shown by *Axonopus semialatus* with 9·8 per cent., and the lowest by *Andropogon amplectens* with 3·7 per cent., a wide variation, but again omitting the extremes there are ten species from *Panicum ecklonii* (9·2 per cent.) to *Anthistiria imberbis* (5·9 per cent.), which lie fairly close together. Only one ruderal species falls within this limit, and most of the pioneer species and post-climax grasses lie below it.

So far as the present data goes, one is led to the conclusion that the different species of the climax veld type all tend to a very similar composition. This is true also of the ruderal and pioneer types, but to a decidedly lesser degree. Species of these types, especially the former, have a more varying habitat than in the case of the climax veld type, and so have greater scope in which to assert their individuality.

Transverse Sections of the Leaf.

With regard to the method of ascertaining the relative values of grasses and similar feeding stuffs, to place them in inverse order of their fibre content appears at once to be simple and satisfactory. This method gives results that are concordant with other methods—*e.g.*, calorific value—and with general agricultural opinion based on practical experience. A study of Table II will illustrate this point.

Dr. Bews[2] states that " much may be learned by studying simple transverse sections of the leaves of the grasses. It is much less laborious and probably even more useful on the whole than elaborate chemical analyses of the herbage, for these, without doubt, vary greatly according to the time of the year end even according to the state of the weather. . . . A glance (at the cross section) is sufficient to show whether each grass represented is likely to prove palatable to stock. The less sclerenchyma shown the more useful is the grass from this standpoint."

The sclerenchyma, of course, corresponds to the " crude fibre " of the chemical analysis, and thus the analyses made confirm this opinion. Bews figures cross sections of a number of the species, or of closely allied species dealt with by the writer, viz., *Andropogon hirtus*, *Anthistiria imberbis*, *Aristida bipartita*, *Digitaria ternata* (allied to *D. horizontalis* and *D. sanguinalis*), *Eragrostis curvula*, *Harpechloa capensis*, *Sporobolus indicus*, *Tricholaena rosea*, and *Tristachya leucothrix*. A classification of these species based on the cross sections as figured would place the species much in the same order as they are found under the heading of crude fibre in Table II.

This method does not taken into account the relative protein content, which in some species—for example, *Rottboellia compressa*, *Eragrostis chloromelas*—differs widely from the relative fibre content. Thus a very important factor from the stock farmer's standpoint is neglected.

Individual Variations.

Species that were collected in successive years at approximately the same period of the year generally show a considerable variation quite apart from the seasonal variation mentioned in the second part of this investigation. In a few cases this was so great as to exceed the difference between these species and those of a similar composition. As mentioned at the outset, this difference is to be expected, and only the repetition of analyses can ensure a fair average. So far as the present data goes, it is difficult to ascribe it to the climatic differences of the years in question, as this variation in composition is decidedly irregular. No doubt the ever-present difficulty of obtaining a fair average sample accounts for part of the variation.

Take the case of *Digitaria sanguinalis*, for example (see Table IV). Here we find that the two samples taken in 1920 and 1921 are very similar in crude fat, fibre, protein and carbohydrates, although the earlier sample is slightly poorer in each of the valuable constituents and slightly higher in fibre, this cumulative deficiency being reflected in the calorific value. The corresponding sample taken in 1922 (that of 7/3/22) shows better results throughout, but on the whole the three analyses are fairly concordant. Also in 1921, within four days of collecting the sample mentioned above, some *Digitaria sanguinalis* was found growing on a neglected piece of ground that had been heavily manured, where it had become most luxuriant in growth. The composition of this sample was found to differ so markedly from all other samples of the species that it has not been included in the average, but shown separately in Table I. Here every constituent—except crude fibre and soluble carbohydrates—shows lower percentages than do any of the other samples of the species. Of course, the total feeding value per acre would greatly exceed the average, but that side of the question has not been dealt with by the writer.

In *Panicum laevifolium* greater variation exists—for example, crude fibre amounts to 39·1 per cent., 31·7 per cent., and 36·7 per cent. respectively in the three years. Protein shows a maximum in the second year and a minimum in the first, although the third year comes very near to the composition of the first The marked general inferiority of the first sample is reflected in the calorific value of 2,250, compared with the average of 2,436 for the whole species.

Setaria imberbis shows a decidedly superior composition in 1921 as compared with the following year, the latter showing a marked falling off in protein especially. As in the case of *D. sanguinalis*, a very luxuriant sample was collected in 1921—on the same day and near the same area as the sample of average growth. The composition of this sample, however, is not so abnormal as in the case of *D. sanguinalis*. It shows a slight inferiority to the average of that year, but not to such an extent as does the sample collected at the same period in the following year.

To take the case of the chief of the grasses of the climax veld—*Anthistiria imberbis* (*Themeda triandra*)—we have samples taken on 1/3/20 and 24/2/22, which give practically identical figures for protein, but the earlier sample is consistently but slightly inferior to the latter one. The two samples of 4/12/20 and 21/12/21 may also be taken as comparable, and here the agreement is remarkably close in all constituents.

Thus the ordinary veld grass proves to be more constant in composition than the more succulent ruderal grasses.

As an extreme case of protein variation, *Leersia hexandra* is included. This year's sample contains more than double the amount of protein as compared with that of two years ago. Both samples came from typical marshy vlei land and from points at no great distance apart.

Seasonal Variations.

In connection with the second part of the investigation, the question of seasonal variations, seven of the commonest and most promising species were selected and samples collected as before, as soon as the flowering stage was reached, whilst anthers were showing and before seed had set. Samples of these species were then taken monthly, as regularly as possible consistent with the observation of the weather conditions as already explained. Generally three samples were taken before growth became too far advanced for the present purpose. The results of this phase of the investigation are shown in Table IV. They are rather variable, but it is too soon to draw definite conclusions on the work of a single year. However, certain points of interest are indicated.

As already noticed, the ordinary climax veld grass, as instanced by *Anthistiria imberbis*, shows the greatest constancy, its composition varying but little throughout the season. The ruderal species show greater variation, due no doubt to the greater susceptibility of their habitat, and of the species themselves, to climatic conditions

Generally, the fibre increases and the protein decreases as the season advances—for example, *Digitaria sanguinalis* and *Panicum proliferum*, where the change is progressive. In others the change is irregular—for example, in *Eleusine indica* and *Rottboellia compressa* the second sample shows more fibre and less protein than either the sample preceding or following it. In *Panicum laevifolium* and *Setaria imberbis*, on the other hand, crude protein is highest in the intermediate stage, the former also showing here an unusually high maximum of "amides," which normally indicates the less mature herbage.

In practically every species, however, taking only the first and last samples of the species, the ash and protein diminish, whilst the fibre and soluble carbohydrate increase, this being the general tendency of maturing herbage. In the present instance, although the aim was to secure samples at as even a stage of

Table IV.

Percentage Composition of Indigenous Grasses.

Results are all calculated on the absolutely dry sample.

NAME.	Type.	Date Col-lected.	Ash.	Phos-phoric Oxide.	Crude Fat.	Crude Fibre.	Crude Protein.	True Protein.	Amides, etc.	Soluble Carbo-hydrates.	Calorific Value.	Nutri-tive Ratio.
Anthistiria imberbis	Veld	1/3/20	6·42	—	2·11	37·32	5·27	4·63	0·48	49·04	2423	1 : 11·7
,, ,, ...	,,	4/12/20	6·90	—	3·63	34·35	6·42	5·92	0·38	48·82	2602	1 : 9·7
,, ,, ...	,,	21/12/21	6·84	0·22	2·86	34·94	6·12	5·60	0·40	49·36	2541	1 : 10·0
,, ,, ...	,,	24/1/22	7·13	0·21	2·56	34·96	6·22	5·45	0·58	49·32	2515	1 : 10·2
,, ,, ...	,,	24/2/22	5·89	0·19	2·70	35·45	5·32	4·54	0·59	50·83	2553	1 : 12·6
Digitaria sanguinalis	R	6/3/20	11·94	—	2·73	30·69	13·09	10·80	1·73	42·11	2517	1 : 4·6
,, ,, ...	,,	21/2/21	9·98	—	2·93	30·35	14·46	10·79	2·76	43·19	2636	1 : 4·8
,, ,, ...	,,	5/1/22	11·94	0·80	3·46	26·18	17·82	13·36	3·36	41·70	2762	1 : 3·8
,, ,, ...	,,	6/2/22	9·89	0·50	2·69	26·93	15·73	12·79	2·22	45·48	2760	1 : 4·1
,, ,, ...	,,	7/3/22	9·95	0·48	2·38	28·85	15·24	12·63	1·96	44·23	2660	1 : 4·0
,, ,, ... (Luxuriant growth).	,,	25/2/21	7·48	—	2·55	33·37	9·20	7·66	1·16	47·78	2573	1 : 7·1
Eleusine indica	R	2/3/20	9·71	—	2·39	35·57	13·08	9·26	2·88	40·19	2407	1 : 5·1
,, ,, ...	,,	21/2/21	7·06	—	1·83	31·52	12·50	9·28	2·42	47·89	2646	1 : 5·7
,, ,, ...	,,	5/1/22	7·49	0·43	2·29	30·34	13·81	9·81	3·02	47·05	2708	1 : 5·5
,, ,, ...	,,	6/2/22	6·16	0·24	2·38	31·79	10·73	8·66	1·56	49·45	2689	1 : 6·4
,, ,, ...	,,	7/3/22	7·40	0·36	2·38	30·29	14·48	10·52	2·98	46·42	2718	1 : 5·1
Leersia hexandra	Vlei	8/3/20	14·76	—	2·07	32·86	6·67	5·98	0·52	43·81	2262	1 : 8·2
,, ,, ...	,,	2/3/22	14·58	0·48	3·20	31·37	14·25	13·00	0·94	36·91	2395	1 : 3·4
Panicum laevifolium	R	28/2/20	8·50	—	1·55	39·07	7·09	5·10	1·50	44·28	2250	1 : 9·5
,, ,, ...	,,	21/2/21	8·39	—	2·02	31·72	9·88	7·24	1·99	48·64	2587	1 : 7·5
,, ,, ...	,,	23/12/21	9·40	0·31	1·93	35·14	11·85	6·97	3·68	42·88	2423	1 : 7·1
,, ,, ...	,,	25/1/22	8·72	0·26	2·06	33·49	9·65	7·33	1·74	46·66	2500	1 : 7·1
,, ,, ...	,,	28/2/22	7·24	0·27	2·03	36·72	7·57	6·12	1·08	46·81	2418	1 : 8·5
Panicum proliferum	R	21/2/21	7·47	—	2·00	33·17	12 02	8·45	2·69	46·22	2574	1 : 6·2
,, ,, ...	,,	23/12/21	9·03	0·44	2·18	29·72	14·39	9·53	3·66	45·88	2674	1 : 5·5
,, ,, ...	,,	25/1/22	8·91	0·24	1·97	31·02	13·88	9·27	3·48	45·35	2612	1 : 5·6
,, ,, ...	,,	25/2/22	7·75	0·26	2·40	31·62	12·36	8·60	2·83	46·80	2649	1 : 6·2
Rottboellia compressa var. fasciculata (from	Vlei	1/3/20	5·92	—	1·64	36·99	4·91	3·92	0·75	50·78	2436	1 : 14·0
vlei)	,,	21/2/21	4·18	—	1·24	39·14	3·33	2·84	0·37	52·23	2393	1 : 19·5
,, ,, ...	,,	24/12/21	5·24	0·36	1·82	33·57	4·10	3·23	0·66	55·48	2612	1 : 18·6
,, ,, ...	,,	6/1/22	4·22	0·24	1·62	37·49	2·75	2·38	0·29	54·00	2477	1 : 24·3
,, ,, ...	,,	6/2/22	5·25	0·30	1·58	37·01	3·37	3·04	0·24	52·88	2453	1 : 18·6
,, ,, ...	,,	7/3/22	5·06	0·26	1·57	34·46	2·77	2·72	0·04	56·15	2562	1 : 22·0
Rottboellia compressa var. fasciculata (Exper.	Vlei	24/12/21	4·73	0·20	1·78	35·15	5·62	4·43	0·90	53·01	2569	1 : 13·0
plots)	,,	26/1/22	5·23	0·23	1·70	35·26	6·56	5·60	0·72	51·49	2538	1 : 10.0
Setaria imberbis (luxuriant growth)	R	25/2/21	8·27	—	2·38	33·82	10·19	7·36	2·14	46·03	2526	1 : 7.1
Setaria imberbis	,,	25/2/21	9·28	—	2·79	30·81	11·96	8·97	2·24	45·91	2632	1 : 6.0
,, ,, ...	,,	24/12/21	8·85	0·45	1·92	32·31	7·81	5·83	1·50	49·59	2532	1 : 9.4
,, ,, ...	,,	26/1/22	8·96	0·31	2·01	34·54	9·22	7·01	1·67	45·81	2443	1 : 7.3
,, ,, ...	,,	28/2/22	9·28	0·39	2·33	34·29	6·71	5·85	0·64	47·61	2444	1 : 9·1

growth as possible, an increasing state of general maturity was almost inevitable even though the flowers were still at the desired stage.

General Ecological Notes.

Many of the foregoing results may be explained and correlated if, in addition to considering the general habitat and classification of the various grasses, attention is also directed to the differences in growth form and ecological life history.

The ruderal grasses which occupy relatively high positions of merit in Tables II and III in the main are annuals—for example, *Digitaria sanguinalis*, *Eleusine indica*. Any annual plant has a widely different physiological behaviour from a perennial. An annual does not store food in its underground parts. It grows quickly and luxuriantly during the favourable—that is, summer—season. It provides for abundant seed production, but until the seed begins to form it retains its stored-up food material in its aerial parts, where it is available for the plant's use. Much sclerenchyma, therefore, is not called for in the structure of such annual grasses. Hence the value of such grasses is necessarily high, both on account of the small amount of fibre present and of the food material stored up, where it is so readily accessible to grazing animals. From these same considerations one would also expect to find considerable variation in these annual species, and this is borne out by the figures in Table IV. Annuals, too, are more readily affected in their composition by weather changes than are perennials, due also to this storage of food materials in their aerial parts. A perennial having its underground supply to draw upon during unfavourable conditions and for seed formation naturally shows a greater stability in its composition.

The general similarity of veld species may be correlated with the general similarity of growth, being of a tufted or bunched habit, while the ruderal species show greater variability in their growth forms. Their successional behaviour differs, however, pioneers being more deep rooted and xerophytic, thus calling for considerable sclerenchyma formation. Species that follow them have a shallower rooting habit, and in their earlier stages demand shade, their sclerenchyma requirements being therefore less.

Another grass of high nutritive value is *Cynodon dactylon*, a perennial creeping form which roots at the nodes. It requires food storage for the perennial renewal of growth, but the food is stored above ground, where it is within reach of grazing animals, there being little underground growth. This creeping habit, then, may be correlated with a less development of sclerenchyma for strengthening purposes, and the rooting at each node means a less distance for water conduction and less lignified conductive tissue.

Vlei grasses are generally of fairly high nutritive value, which may be considered in relation to their habitat. Their water supply is normally abundant, so that any great development of water conducting tissue is not needed. *Leersia hexandra*, however, is

of little use to the farmer, as it is rarely eaten by stock, being rather harsh to the touch, due probably to the excessive proportion of silica present, as shown by the high percentage of ash, much of which is insoluble in acids.

Cyperus esculentus is typically hygrophilous and of a simple unbranched habit of growth. Hence its position on the list as the lowest in fibre is readily correlated with the fact that little sclerenchyma and conducting tissue are required.

Rottboellia Compressa.

In *Rottboellia compressa* we have an ecological point of some interest. At Cedara in January, 1920, an experimental plot of Rottboellia was planted on a typical hillside soil, well drained, and quite different in type from the vlei soil of the farm where this species finds its home, and whence young plants were obtained for establishing this plot. The results were remarkably good, although no figures were obtained as to the weight of hay produced per acre. The grass flourished under its new conditions, without being specially watered or treated in any way once it had become established. It matured more rapidly and reached the flowering stage some two or three weeks earlier than in the neighbouring vlei. Its life, however, was shorter, as it became fibrous and its leaves withered sooner than in the vlei. Had it been mown or grazed off no doubt the period of growth would have been prolonged. Hence it was possible to collect only two samples before it became so coarse and rust-affected that an analysis would be misleading.

The samples from this trial plot were fairly uniform in composition, showing rather more protein in the later sample. The corresponding samples in the vlei series are those taken two weeks later than in the experimental plot, and these two also show similar variation. The first vlei sample, taken on 24/12/21, was somewhat immature, and hence is not used in comparing the two series.

The plot samples show slightly less fibre but much more protein—nearly twice as much as in the vlei samples. Ash and crude fat are very slightly higher, calorific value is decidedly higher, and nutritive ratio much narrower. Thus a grass that is relished by stock and has good feeding value has its main defect, its lack of protein, remedied by change of habitat. Further, by making its environment more akin to that of the ordinary veld its composition seems to tend towards that of the climax grasses.

Phosphate Content of the Ash.

At the suggestion of Dr. Green, of Onderstepoort, the scope of the present work was increased so as to include the phosphate content of the ash. On account of the known general deficiency in phosphates of the soils of South Africa, and hence the deficiency of this constituent in the ash of veld grasses—to which is attrib-

uted much of the cattle diseases of this country—it is of interest and value to obtain definite figures as to the amount of this important constituent of the ash of the common veld grasses.

Unfortunately, as this phase was only taken up this year, results are based on a single sample only, except for those results appearing in Table IV. In the ordinary climax grasses the amount of phosphate present is remarkably constant, averaging a little over 0·2 per cent. of the absolutely dry grass. In the ruderal species the figures show considerable variation, averaging between 0·3 per cent. and 0·4 per cent.

By way of comparison the following figures are quoted after recalculating to dry matter:—

Meadow hay (Crowther[15]), 0·46 per cent. phosphoric oxide.
Pasture grass (Crowther[15]), 0·60 per cent. phosphoric oxide.
Teff hay (Vipond[6]), 0·22 per cent. phosphoric oxide.

The method of determination adopted was Vipond's[6] modification of the methods of von Lorenz and Pemberton. The ash as obtained in the general analysis was taken up with dilute nitric acid, the phosphate precipitated as phosphomolybdate, dissolved in a known volume of N/10 KHO solution, and the excess titrated back with N/10 H_2SO_4 solution, from which the amount of phosphoric oxide is calculated.

Summary.

1. Ruderal grasses usually have a better composition and a higher feeding value than do the ordinary grasses of the climax veld, whilst pioneer and post-climax grasses are generally coarse and inferior in feeding value.
2. The composition of grasses of the climax veld tends to uniformity, that of the other types, especially ruderal, being more variable.
3. Individual and seasonal variations are considerable, especially as regards the ruderal species. These variations are irregular and cannot be accurately ascribed to any definite cause or causes until further data is available. No doubt the ever-present difficulties of sampling may account for a part of these variations.
4. The above facts may be explained and correlated to a considerable extent if they are viewed in the light of the differences of the species in growth form and in ecological life history.
5. *Anthistiria imberbis* (*Themeda triandra*), the principal veld grass from the stock farmer's point of view, has also about the best composition and feeding value of the grasses of its type.
6. The crude fibre content affords probably the best criterion for determining the relative feeding values of grasses, the feeding value being in inverse ratio to the fibre content.

7. A cross section of the leaf shows by inspection the approximate relative fibre content, and hence the relative feeding value of the grasses.
8. *Rottboellia compressa*, a vlei grass, grows well in an experimental plot on hillside soil at Cedara, giving a large yield per acre, and greatly increasing the protein content, the main defect of this grass as naturally occurring on the vlei. On hillside soils *Rottboellia* tends towards the composition of climax veld grasses.
9. The phosphate content is very constant for the average veld grass, being about 0·2 per cent. of the dry matter of the grass. In ruderal species the amount is about 0·3 per cent. to 0·4 per cent., and this is rather variable.

In conclusion, the writer wishes to acknowledge his indebtedness to Dr. Bews, of the Natal University College, and to Mr. C. O. Williams, Chemist, School of Agriculture, Cedara, Natal, for advice and assistance so willingly given.

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A NOTE ON THE OCCURRENCE OF *APHELENCHUS PHYLLOPHAGUS* IN CHRYSANTHEMUMS IN THE TRANSVAAL, WITH SUGGESTIONS FOR ITS CONTROL.

BY

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Read July 10, 1922.

The following note has for its purpose the recording of the presence in the Transvaal of *Aphelenchus phyllophagus*, a malignant pest which, when well established, may seriously menace the culture of chrysanthemums.

The parasite, a nematode, was recorded for the first time in England by F. H. Stewart during 1921, and is apparently not unknown in other parts of Europe. Its presence in South Africa was brought to my notice by a sample of diseased leaves kindly forwarded to me by Mr. Haines, of the Division of Entomology, Pretoria, who had received the specimens for investigation from Mr. A. J. Atkin, of Parktown, Johannesburg. Mr. Atkin has informed me that for two seasons his chrysanthemums have suffered from a wilting disease, which reached its climax when the plant was nearly full grown, and effectively retarded the development of the flower buds. I have since found infected plants in other suburbs of Johannesburg, where, on making inquiries, I was informed that, in the opinion of the grower, the plants were infected with mildew or rust, the symptoms of which diseases closely resemble those produced by *Aphelenchus*. The parasite has no doubt been introduced into this country by " slips " or cuttings from Europe, and is apparently of relatively long standing.

The morphology and biology of *Aphelenchus phyllophagus*, the parasite here concerned, have been very adequately described by Stewart (*Parasitology*, XIII, pp. 166-179), and it is therefore deemed unnecessary to discuss this question further than to state that *Aphelenchus* belongs to a group of plant parasitic nematodes which are of no mean economic importance in consequence of their depredations to agricultural and horticultural crops. There are three genera of nematodes chiefly involved in this parasitic rôle, namely, *Heterodera*, *Tylenchus*, and *Aphelenchus*. *Heterodera* is easily distinguished from the latter two parasites on account

of the profound metamorphosis undergone during its life-cycle, and *Tylenchus* differs from *Aphelenchus* in that the male possesses an inconspicuous "bursa copulatrix." *Aphelenchus*, in common with the two other genera, is provided with a chitinous boring organ or "spear" whereby the parasite is able to penetrate the tissues of the host plant. *A. phyllophagus*, as the name indicates, is parasitic on the leaves. Very occasionally it may be found located in other parts of the plant. The present author found only one or two individuals in the parenchyma of the stem of an old, severely-infested plant. This, however, appears to be abnormal, and in our case was possibly accidental.

The route whereby the parasite reaches its definitive habitat, as recorded by Stewart, is by making its way up the surface of the stem of the plant into the leaf axils, where, incidentally, the female may deposit her eggs. The eggs on hatching produce relatively thin, small larvae, which creep on to the under-surface of the leaves and invade the mesophyll viâ the leaf stomata. Soon after infection (about one week) the leaf becomes marked by a brown area, which increases in size until eventually the leaf wilts and falls from the plant. The parasites multiply rapidly in the leaf, and a severely-infected leaf may contain as many as sixty individuals in all phases of development.

Control.

From personal examinations of the soil it was only occasionally that I found a few specimens of the parasite. Usually there were only four or five individuals which could be positively identified as *Aphelenchus*, found in small watch-glass samples of soil taken from pots with infested plants. Those few found were larvae, that only revived after some considerable time in water. On the other hand, leaves, which had fallen from the plants and had remained on the ground for as long as three months, were found to contain large numbers of the parasites that speedily revived after immersion in water.

The leaf, then, must be regarded as the reservoir of the parasite during the winter period. The infected leaves should, therefore, be systematically destroyed by burning. This should constitute the chief prophylactic measure to be employed in combating the disease, as, when neglected, the leaves may fall near the dormant stool of the plant and act as the centre of infection. Leaves on the growing plant might also be removed profitably as soon as infection becomes evident.

Chemicals as a Means of Control.

Stewart, on the authority of Mangin (1895), states that it is only in the case of plants such as Everlasting, where the flowers are stored in warehouses, that chemical treatment is of any use. "Exposure to a dry atmosphere saturated with carbon bisulphide for 24 to 48 hours kills the parasites without affecting the appear-

ance of the plants. In no other plants has chemical treatment of any kind been found of avail, since chemicals of sufficient strength damage the appearance of the plant." Our own limited experience, strange to say, has given quite different results. Mr. Atkin was good enough to experiment on some of his plants with the following results: (1) It was found that placing the plant in an atmosphere of carbon bisulphide for as short a period as an hour only produced the death of the plant, and so this method had to be discarded.

(2) A spray of dilute potassium sulphide (one ounce to four gallons of water) was found very efficient. K_2S, or, as it is sometimes known in commerce, "Liver of Sulphur," has long been known as a fungicide in the treatment of rusts, mildew of roses, carnations, etc. It must, however, be employed in very dilute solution, otherwise ill effects appear on account of the sulphuretted hydrogen generated. In the case of chrysanthemums parasitised by *Aphelenchus*, the plants were sprayed once a week, special care being taken to ensure the undersides of the leaves receiving the spray. It is also advisable that the spray be renewed after any heavy rains. In the present instance, chrysanthemums of many varieties, among which were Colonel Appleton, Commonwealth, Mona Davies, Rosy Morn, Thorpe's Beauty, Joseph Stoney, Fred Green and others, were treated and appeared to derive substantial benefit within a very short time. On the other hand, plants which were kept as a check or control and remained unsprayed gradually succumbed as a result of defoliation. The spray caused no ill effects to the leaves or blooms after treatment.

Acknowledgment.

I have much pleasure in thanking the Research Grant Board for a grant-in-aid for these and other helminthological researches of mine.

THE INFLUENCE OF THE COOLING POWER OF THE ATMOSPHERE ON THE RATE OF GROWTH OF YOUNG ANIMALS.

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The various forces influencing the growth of young animals may be grouped under two headings: an internal factor which has been termed the growth impulse, and an external or nutritional factor. The growth impulse is complex, and it is as yet impossible to resolve the multiplicity of factors concerned. It represents the power to grow inherent in the ferilised ovum, in which must be pre-determined the extent to which such important factors as endocrine secretions and "tissue tension" will function in the growing organism.

For the complete development of the fertilised ovum to take place—that is, for the perfect growth pre-determined by the growth impulse to result—there must be ideal conditions of the external or nutritional factor. The growth impulse would be entirely ineffective if the external factor were absent. Thus an acorn with the growth impulse to produce an oak would remain an acorn if kept in an atmosphere of nitrogen. This external factor is also multiple, and represents the sum of those external factors which influence growth. Important amongst these are (1) the nature and amount of the food presented to the young animal; and (2) the atmospheric or climatic conditions to which the young animal is subjected.

It is evident that for ideal growth to take place the food supply must not only be adequate, but must contain the ingredients necessary for the manufacture of the various tissues of the animal. Further, it has been established that, in the absence of certain accessory substances or vitamins, these ingredients cannot be built into the structure of the body. All three known vitamins are necessary for normal nutrition to take place; but it would appear that two of them are more particularly necessary for the incorporation of the ingredients of food in the body of the young animal, resulting in the growth of that animal, to take place. These are the fat-soluble A and the water-soluble B vitamins.[1*]

Of the atmospheric conditions which may influence growth, two have received attention: the atmospheric pressure, and the cooling power of the atmosphere. It has been suggested that prolonged exposure to the low atmospheric pressures obtaining at such high altitudes as in the settlements in the Andes result not only in an increased manufacture of red blood corpuscles,

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*These numbers refer to the papers listed in the References.

but also of muscular tissue.[2] For some time after an adult individual has settled at one of these high altitudes the nitrogen output is less than the nitrogen intake. There is an actual building up of new muscular tissue.

The profound influence of the cooling power of the atmosphere on the metabolism has been abundantly demonstrated.[3] Leonard Hill has provided us with an instrument, the kata thermometer, by means of which the cooling power of the atmosphere can be readily determined. It is found that for active metabolism to take place in mammals, a moderately high cooling power of the atmosphere is desirable. In some mammals the response to very high cooling powers is by a partial arrest of metabolic activities as occurs in hibernating animals in winter, when there is a prolonged period of high cooling powers. This habit is evidently to be explained as an adaptation to the lessened food supply in winter rather than as a direct reaction to a high cooling power. If the animal, in the hibernating condition, be submitted to extreme conditions of cold, its metabolic activities increase and the animal wakes up; thus death from freezing is prevented.

Observations made on guinea pigs last summer in Johannesburg revealed the fact that the animals invariably ate more during the cool spells of weather than during the more usual hot spells. This is shown in Table I. During the first ten days of February

TABLE I.

Amount of Food Eaten by a Guinea-Pig during Cool and Hot Periods in Summer.

Date.	Cooling Powers*		Ration Offered.		Ration Consumed.	
	Dry Kata.	Wet Kata.	Milk.	Oats and Bran.	Milk.	Oats and Bran.
			gm.	gm.	gm.	gm.
Feb. 1	3·5	21·8	200	50	200	35
2	7·7	21·8	270	50	270	50
3	5·4	18·6	400	50	280	50
4	5·0	17·3	400	50	280	30
5	4·9	17·9	320	50	290	32
6	3·5	16·2	320	50	245	36
7	5·1	18·6	320	50	320	50
8	6·7	23·9	320	50	100	50
9	5·3	20·0	320	90	90	75
10	6·3	20·9	320	90	320	46
Cool period average ..	5·3	19·7			239·5	45·4
15	3·6	20·9	200	90	107	31
16	3·9	23·9	240	90	170	47
17	3·4	15·65	240	90	90	40
18	3·2	14·3	240	90	80	20
19	3·2	15·2	240	90	50	50
20	4·7	19·3	240	90	148	25
21	4·1	18·6	400	100	200	30
22	3·7	16·7	400	100	80	70
23	3·7	14·7	320	100	145	50
24	3·7	15·65	320	100	90	46
Hot period average ..	3·7	17·5			116	40·9

*Millicalories per sq. cm. per second.

The Kata readings were taken in the Animal Room at 12 a.m. each day. The weight of the animal was 520 gms. on Feb. 1 and on Feb. 24. During that period it did not rise above 525 gm. or fall below 500 gm.

the weather was cool owing to rains. The daily cooling power of the atmosphere averaged 5·3 units dry kata at noon. The average daily consumption by the animal under observation was 239·5 grammes of milk and 45·4 grammes of oats and bran. From the 15th to the 24th of February the weather was hot, the cooling power averaging 3·7 units dry kata at noon. The animal consumed on an average 116 grammes of milk and 40·9 grammes of oats and bran. Apart from the variations in the atmosphere, these animals were kept under uniform conditions. The nature of the diet was constant. Further, one may assume that these lowly animals are not much influenced by affective states, pleasurable or otherwise. Since the animals were not stimulated to eat more because of increased tastiness of the food, nor less because of depressed mental conditions as might occur in human beings, one appears to be justified in assuming that the amount eaten is a direct criterion of the metabolic activity of the animal. Under these circumstances the only stimulus for increasing eating would be increased tissue hunger.

Hill and Campbell showed the stimulating effect of high cooling powers on the metabolism of children exposed more or less nude to the conditions obtaining during the Alpine winter.[4] This influence on the metabolism would be expected to reveal itself in an increased rate of growth of infants in cool weather. The summer of the Transvaal contrasts markedly with the winter, and as the latter is seldom excessively cold, a comparison of the rate of growth of infants in the two seasons should reveal whether or not growth of infants is more rapid during a season of comparatively high atmospheric cooling power.

At the Infant Clinic conducted by the Municipal Council of Johannesburg the infants are systematically weighed. The records of nineteen normal infants under one year in age were tabulated as shown in Table II, the increase in weight during the summer months, October to March, being compared with that during the winter months, April to September. It is seen that for these infants the average monthly increase in weight was 0·79 pounds in summer and 1·46 pounds in winter. These infants all came from the poorer quarters of the town, where it is probable that exposure to cooling is greater than in the more comfortable homes of the wealthy. This has an important clinical bearing. It would appear that in Johannesburg the conditions to which infants are normally exposed in summer are not ideally suited for growth. The growth impulse is hampered by the warm summer conditions, being much more effective under the cooler winter conditions. In Johannesburg, and more so in towns such as Lourenço Marques, which have very warm summers, every effort should be made to expose the infants to high cooling powers, if ideal conditions for the growth impulse are to be obtained. The minimum of clothing, the maximum ventilation of buildings, and outdoor sleeping are of extreme importance.

TABLE II.

Increase in Weight of Infants in Johannesburg during Summer and Winter Months.

Summer Months. Oct. Nov. Dec. Jan. Feb. March.			Winter Months. April. May. June. July. Aug. Sept.		
Age at first weighing in months.	Number of complete months.	Increase in weight in pounds.	Age at first weighing in months.	Number of complete months.	Increase in weight in pounds.
8	1	0·25	6	2	1·25
			7	1	2·25
			6	1	1·75
	4	1·25	5	1	2·25
			7	1	1·0
			6	3	5·75
	2	1·0	1	5	6·25
	5	4·0			
	5	5·25			
4	4	3·5	2	1	1·0
7	5	3·0	2	5	7·5
7	4	4·0	3	4	4·0
6	6	1·75	1	5	6·5
3	6	6·4	1	2	5·25
1	5	5·6			
2	5	3·9			
3	6	4·25			
1	4	4·5	1	2	3·5
1	4	3·4			
Total	66	52·05	—	33	48·25
Average Monthly Increase in Weight ..	—	0·79	—	—	1·46

Even more convincing evidence of the stimulating effects of high cooling powers on growth are obtained from an analysis of figures published by W. T. Porter.[5] His observations were made in Boston, U.S.A., on several thousand children over a period of several years. Reference to Table III shows a very marked

TABLE III.

Gain in Weight of Boys and Girls born in August, 1905 (Boston).

Year.	Boys.		Girls.	
	September to January.	February to June.	September to January.	February to June.
	pounds.	pounds.	pounds.	pounds.
1912-13	3·34	—0·75	1·88	0·12
1913-14	2·17	—0·17	2·50	0·65
1914-15	2·85	0·67	2·96	0·13
1915-16	1·29	0·81	1·63	0·71
1917-18	5·83	—0·07	3·19	0·81
1918-19	4·88	2·90	4·63	1·83
Average	3·40	0·82	2·79	0·71
Ratio	$\frac{3\cdot40}{0\cdot82}$ =	$\frac{4\cdot1}{1}$	$\frac{2\cdot79}{0\cdot71}$ =	$\frac{3\cdot9}{1}$

difference in the gain in weight between the cool and the warm periods. September to January is the autumn-winter period in Boston. It is seen that during this period the gain in weight is four times more rapid, on an average, than during the period February to June.

I have for some time been conducting experiments on the rate of increase of weight of young animals, especially pups, under various conditions of cooling. Pups from the same litter are kept in cages placed (*a*) in a warm engine-room, (*b*) in a room kept artificially cool by fans and ice, (*c*) in an ordinary room. Kata thermometer readings are taken three times a day in each room, and the weight of the animals is recorded daily. These experiments have not yet proceeded very far, but it is already very evident that the most rapid increase in weight takes place in pups exposed to the highest cooling powers.

The tables in this paper have already appeared in a statement of the ventilation problems of Johannesburg.[6] I venture to place them before you in the hope that further information as to the influence of cooling power on growth may be revealed. In particular, I have found it very difficult to obtain reliable records of the growth of infants in warm and cold seasons, in spite of much correspondence on the matter.

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ON THE INCIDENCE OF KERATOMALACIA AMONG RATS SUFFERING FROM AVITAMINOSIS.

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Keratomalacia or xerophthalmia is an affection of the eyes which is associated with deficiency of Vitamin A. It has been particularly noticed among rats used for vitamin experiments.

It has been well known for some time that a primary symptom of malnutrition among children is a conjunctivitis due to lowered resistance, which offers a focus for bacterial invasion at one of the weakest points in the body. Histologically it has been shown that the condition, among rats fed on a diet deficient in Vitamin A, results from a breakdown of corneal tissue caused by bacterial invasion, which only occurs after a prolonged course of diet deficient in Vitamin A (Stephenson and Clark, 1920).[1*] The American workers, Osborne and Mendel (1921),[2] have shown that in experiments on 1,000 unselected rats, xerophthalmia was only seen in animals with deficient fat-soluble vitamin: in this group—the number of animals involved is not stated—the incidence was 50 per cent., most of the cases developing before any marked decline in body weight had occurred. Administration of Vitamin A—for example, 0·1 gm. of butter-fat per day—caused the disappearance of the eye disorder, even though in some cases the animal subsequently died.

Another worker (Emmett, 1920)[3] had previously described experiments on 122 rats, 120 of which developed xerophthalmia.

In view of the discrepancy in the results of these workers, the following details, collected by the author during the course of thirteen experiments upon the vitamin content of various oils and fats, may be of interest. One hundred animals were involved in these experiments: 44 were fed with a fat known to have been deprived of Vitamin A by steam distillation (Stammers, 1921),[4] and the remaining 56 upon fats of varying degrees of deficiency.

Of the 44 on the totally deficient diet, 40 were young animals (33-49 days old) at the commencement of the experiments, and of these 35 developed keratomalacia between the 31st and the 80th day of the experiment. The remaining 4 were adults, 145 days old, when they were used for experiment, and they all developed the condition between the 104th and 129th days of the investigation. Those animals, 56 in number, upon the partially-deficient diets were not so susceptible, 24 only being affected between the 35th and 98th days.

From an examination of the table appended, which gives details of these experiments as far as they relate to the incidence of keratomalacia, the following deductions may be made:—

* The small numbers refer to the papers listed in the References.

Incidence of Keratomalacia among Rats.

	Type of Diet.	No. of animals in expt.	Average weight and age at commencement.	Average weight and age at conclusion.	Days of experiment on which Keratomalacia appeared.	Total affected.	Days of experiment on which animals died.	Total mortality.
1.	Totally deficient ..	8	77 g. .. .. 42 days.. ..	82 g. .. 112 days ..	35, 45, 49, 52, 56. (2) (3)	8	56, 59, 63, 66, 70. (2) (2) (2)	8
2.	.. .. ..	8	48 g. .. .. 33 days.. ..	86 g. .. 124 days ..	31, 38, 42, 45, 63. (2)	6	52, 56, 66, 70, 73, 80. (2)	7
3.	.. .. ..	8	58 g. .. .. 36 days.. ..	70 g. .. 127 days ..	38, 42, 45, 49, 59, 66.	6	49, 59, 63, 73, 84. (2)	6
4.	,, ,, ..	8	60 g. .. .. 49 days.. ..	65 g. .. 150 days ..	31, 35, 42, 52, 66, 70, 77. (2)	8	63, 80, 87, 101.	4
5.	,, ,, ..	8	55 g. .. .. 35 days.. ..	53 g. .. 136 days ..	35, 42, 45, 49, 66, 73, 80.	7	66, 84, 87. (2)	4
6.	Adults	4	214 g. .. .. 145 days.. ..	174 g. .. 297 days ..	104, 108, 122, 129.	4	143, 150.	2
	Total in Experiments	44			Total affected	39	Total mortality	31
7.	Partially deficient ..	8	77 g. .. .. 42 days.. ..	94 g. .. 129 days ..	77	1	—	0
8.	,, ,, ..	8	48 g. .. .. 33 days.. ..	104 g. .. 124 days ..	73, 84. (2)	3	—	0
9.	,, ,, ..	8	44 g. .. .. 43 days.. ..	112 g. .. 144 days ..	—	0	—	0
10.	,, ,, ..	8	53 g. .. . 49 days.. ..	74 g. .. 150 days ..	35, 49, 56, 63, 66, 80, 98.	7	70, 84, 91, 94. (2)	5
11.	,, ,, ..	8	54 g. .. .. 49 days.. ..	61 g. .. 150 days ..	66, 77, 80, 94.	4	63, 87, 98.	3
12.	,, ,, ..	8	59 g. .. .. 45 days.. ..	79 g. ..6 146 days ..	45, 52, 66, 73, 80.	5	87, 98.	2
13.	,, ,, ..	8	59 g. .. .. 45 days.. ..	90 g. .. 146 days ..	38, 63, 73, 77.	4	84, 98.	2
	Total in Experiments	56			Total affected	24	Total mortality	12

The figures in brackets refer to the number of animals.

In the totally deficient group—that is, in the first six experiments—keratomalacia supervened in 88·6 per cent. of the animals under observation, two-thirds of the cases appearing before the 60th day of the experiment, except in the case of the adult animals.

In the other group, 42·8 per cent. were affected, and two-thirds of the cases appeared after the 60th day.

It therefore appears that the susceptibility of the animals and the time of incidence of the disease vary directly with the amount of Vitamin A in the fat under examination. Also, adult animals are less susceptible to a deficiency of Vitamin A in the diet than are young animals, since the symptoms of the disease were not exhibited in these animals until the 104th to the 129th days, but that nevertheless all four animals were affected and two ultimately died.

Further, it is interesting to notice the mortality among the two groups. In the first group, 31 of the 39 affected animals died, and in the second group 12 out of 24. These deaths all occurred during the progress of the experiments. No further records were kept of those animals which survived till the termination of the experiments, so that it is possible that the mortality may have been higher still.

Attention is also drawn to the fact that in the partially-deficient group most deaths occurred among the animals that had the least amount of Vitamin A in the diet, as evidenced by the growth curves recorded.

The experiments on those fats in which a fair quantity of Vitamin A was present showed no deaths at all and only four cases of keratomalacia, all occurring late in the experiment, among the 24 animals involved.

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THE BLOOD OF EQUINES.

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The blood plays such an important rôle in the physiology of the animal that its study is of very great interest, and from the point of view of disease, of the utmost importance.

The blood is directly or indirectly concerned with every phase of body activity, but only a few of its many functions need be mentioned to show its importance to the animal. Thus the blood carries oxygen from the lungs to the tissues, and carries carbon dioxide from the tissues to the lungs for excretion; it serves to distribute foods to the tissues, and to remove waste products from these for excretion by various organs such as the kidneys; it carries various chemical messengers (hormones such as adrenaline) from the organs elaborating them to the organs where they are needed; it is concerned in heat dissipation, and from it are derived, directly or indirectly, the various secretions and excretions, such as urine and sweat, the saliva needed in chewing food, the gastric and enteric juices needed for the digestion of the food.

The blood in disease is just as important to the animal body as in health—even more important from certain points of view. Thus the blood may directly or indirectly combat disease, or may actually be the means of carrying disease from one part to another; and finally may even become diseased itself.

From this it may be inferred that the blood is often studied for the sake of the information it can give about disease. But any information about blood during disease is only of value if the corresponding data in health are available, and hence the necessity for studying healthy blood.

The blood of man has received very great attention during recent years; that of animals very much less. Extensive data have been obtained, and until the contrary be proved, it may be assumed that the facts established for man will hold for animals, and the reverse.

In this paper a few properties of healthy blood will be dealt with.

The blood consists of a fluid part in which are suspended numerous minute semi-solid bodies, the so-called "formed elements." These formed elements are somewhat heavier than the fluid part, and if blood, prevented from clotting, be allowed to stand, they gradually sink and settle in the bottom of the vessel. The upper or fluid part, called plasma, is now seen to be more or less transparent and to vary in colour from a pale to a dark amber. In the bottom of the vessel the mass is dark red, and above this there is a very thin whitish or greyish layer. Microscopic examination shows that both the red and grey layers are composed of cells, and these cells are called respectively the red corpuscles or erythrocytes, and the white corpuscles or leucocytes.

The Erythrocytes.

These are the cells more particularly concerned in the transportation of oxygen from the lungs to the tissues. The red colour of the erythrocyte is due to hæmoglobin, and it is this substance which actually carries the ogygen. In the capillaries of the lungs the erythrocytes are only separated from the air in the alveoli by a thin membrane through which oxygen can pass easily. Here then the hæmoglobin of the erythrocytes combines with the oxygen of the air to form a compound "oxyhæmoglobin," which can be broken down very easily again. In the tissue capillaries the state of affairs is partially reversed, the oxyhæmoglobin being dissociated and the oxygen so liberated being used by the tissues.

The amount of hæmoglobin in the blood is thus the important factor determining the amount of oxygen that can be carried to the tissues under any given set of circumstances, and since the hæmoglobin is contained in concentrated form in the erythrocytes, their number is an index of the amount of oxygen that can be carried.

It is quite easy to estimate the amount of hæmoglobin in the blood, and also to count the number of red cells per unit volume. From these data it has been ascertained that in health the amount of hæmoglobin per erythrocyte is fairly constant, although some variations occur.

The number of erythrocytes per unit volume of human blood is fairly constant during health, and approximates to 5 millions for men and 4½ millions for women in every cubic millimeter of blood. Variations from this normal figure are often noted, however, and in general it is found that the figure is higher for robust active individuals, and lower for obese. In the case of children it was found that the counts of erythrocytes were as a rule higher after long vacations than at the end of the school term. But those variations are not great—at any rate, they do not extend into millions.

With increasing altitudes, however, the erythrocyte count of man rapidly increases, sometimes by as much as two millions and even more. This change is noted very soon after the person reaches the high altitude, and is undoubtedly the most conspicuous alteration in human blood during health. Compared with other normal variations this change is remarkable, and much stress is laid upon it in text-books.

The less conspicuous changes already referred to are accounted for by "sex" in the case of women, and by bad hygienic conditions (in the broadest sense) in the case of school children and individuals of the same sex; even age is said to influence the erythrocyte count in man.

The few available published data about horse blood seemed to indicate that the same constancy of erythrocyte count existed. Thus eleven authors, quoted by Burnett in his text-book, give erythrocyte counts varying from 6·3 to 8·4 millions per c.mm. The figures now obtained by us, however, prove conclusively that in the horse the erythrocyte count is subject to enormous variations during health—the range being from about 4 to about 13 millions per c.mm.

In the human being in health a range of variation of about 2 millions in erythrocyte count is considered remarkable; by comparison, the range of *variation of over 8 millions* observed for the erythrocyte count of healthy horses is really astonishing—and equally astonishing is the fact that sex, hygienic conditions and age have very little, if anything at all, to do with this. Moreover, this range was obtained for animals at and about Pretoria, and hence altitude is not a responsible factor. Frei, who worked in this Laboratory some years ago, obtained erythrocyte counts which showed similar variations, but could find no explanation.

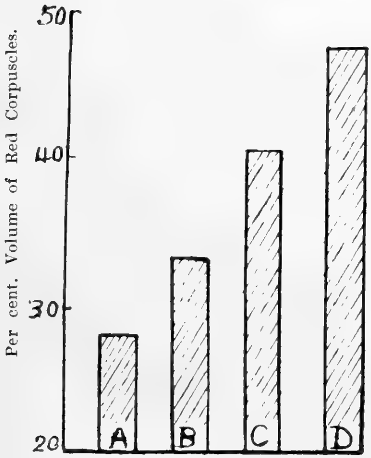
The clue to the correct interpretation of these variations was given by two animals kept under observation for a long time. The first was a riding horse, and its erythrocyte count was always about 9 millions per c.mm. The second horse was permanently stabled, and its erythrocyte count was always about 5½ millions. The stabling and the food of each were the same—only the one horse worked, and the other led a life of idleness.

This clue was followed up by grouping the animals according to the amount of fast work they did as "stabled," "fast working" and "other" horses, the last group including all those horses whose histories were not known. It was then seen that, without exception, every stabled idle animal had a very low erythrocyte count as compared with the high figure noted for every fast-working horse, and that exercise is therefore a most important factor determining the number of erythrocytes in horses.

In order to obtain further evidence of this fact some racehorses in full training were bled, and the erythrocyte counts found to be exceptionally high—always in the neighbourhood of

10 millions. The average figures obtained for the various classes of horses are given in Graph 1 as percentage volumes of red corpuscles in the blood. In the horse there is a constant ratio between the percentage volume of the red cells and their number. If the percentage volume of the erythrocytes be divided by 4·35, the figure so obtained is the erythrocyte count in millions. Conversely, the erythrocyte count in millions, multiplied by 4·35 gives the percentage volume of the red cells in the blood.

Graph I.



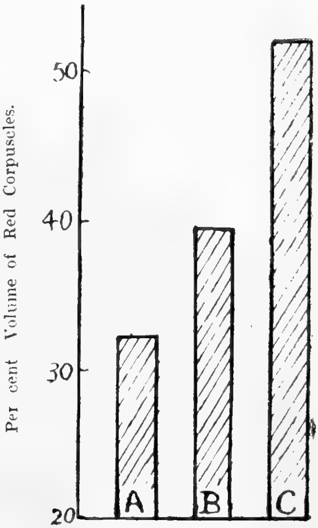
A—Average for Stabled Horses.

B—Average for Medium Horses.

C—Average for Fast-working Horses.

D—Average for Race Horses (in full training).

Graph II.



A—Mare (untamed and untrained).

B—Daughter of Seclusion (Riding Mare).

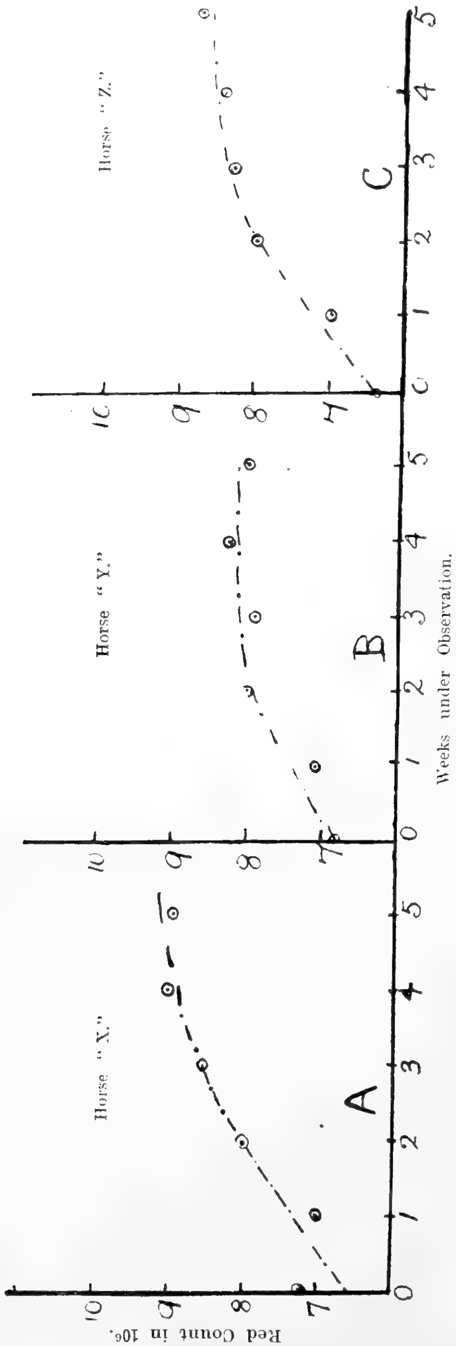
C.—Greentop (in full training).

Percentage Volumes of Red Corpuscles in the Blood of Various Classes of Horses.

So far all the work had been done upon nondescript animals, most of which were intended for horse-sickness experiments. To exclude the possibility of "breed" being an important and deciding factor in the production of the blood picture, three race-horses from the same stable, but in different stages of training, were examined. The figures are given in Graph II, and confirmed the already conclusive evidence obtained previously.

Three young racehorses were then kept under observation for five weeks during their period of hard training. Even in so short a time as this a marked increase in erythrocyte count was noted, as shown in Graph III.

Graph III.



Showing the Influence of Training upon the Red Count.

These results (Graphs I to III) leave no doubt that *in the horse the erythrocyte count increases, within limits, with the amount of hard fast work.*

When viewed in the light of the evolutionary history of the horse the results obtained are perhaps not so startling. In the past the horse depended for its very existence upon its speed and endurance, two qualities only possible with a highly-efficient system for carrying oxygen to the tissues. The modern horse possesses a potential capacity for speed and endurance, and these, as we now see, can be realised by training. During this training the muscular capacity of the animal develops, and concurrently with this the capacity of the blood for carrying oxygen increases through an increase in the number of normal erythrocytes.

The influence of work upon the erythrocyte count is really remarkable. The animal kept absolutely without exercise for a sufficient time may show an erythrocyte count of only one-third that of a fully-trained racehorse. This means that about eight million erythrocytes per c.mm. of horse blood may be formed by the tissues purely as a response to work. Does work influence the blood picture in man, and in animals other than equines? The question at least opens a promising field for future investigation.

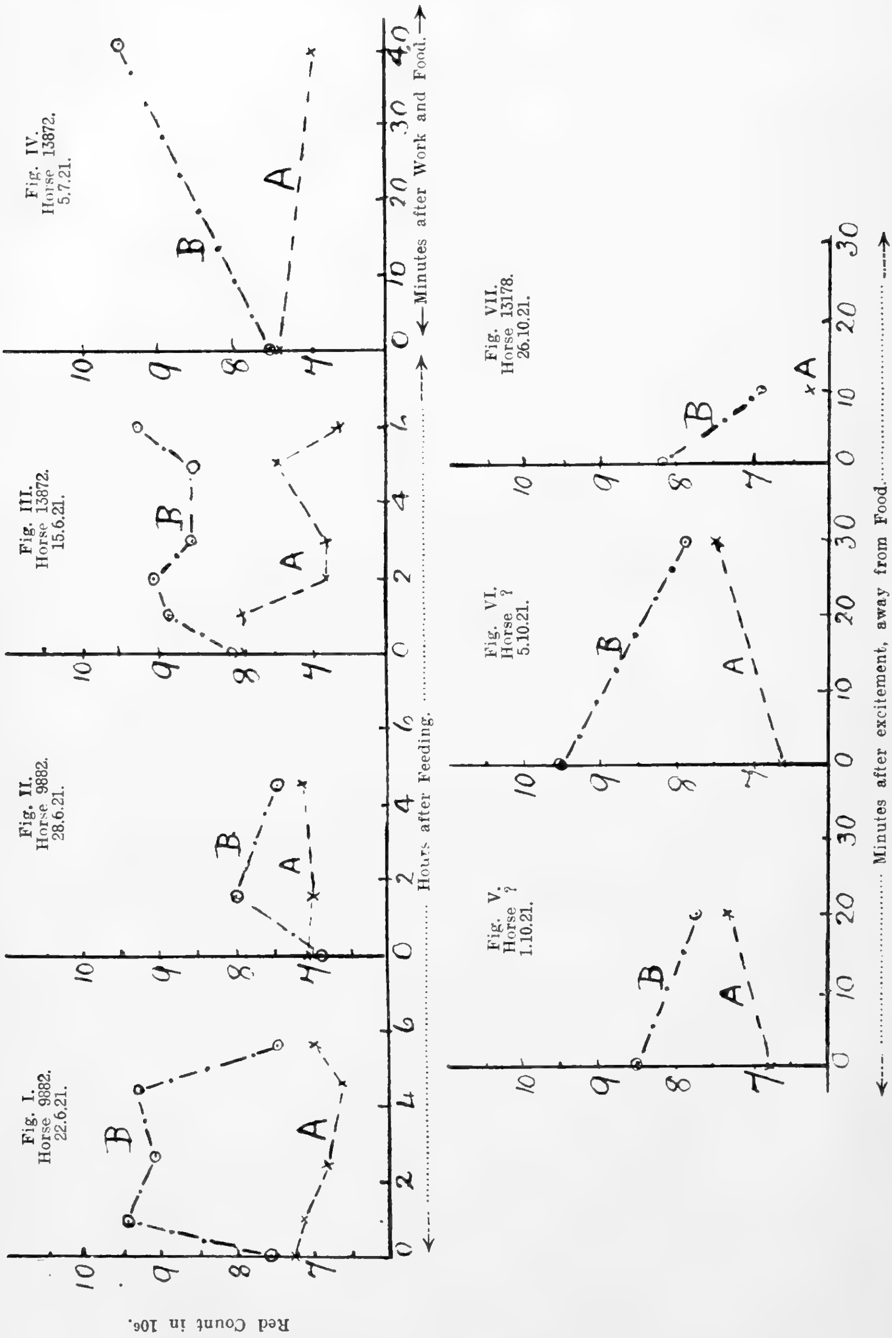
Diurnal Variations.

Many horses were kept under observation for long periods of time, and it was noted that in any individual the erythrocyte count, though fairly constant, showed minor variations, not only from day to day, but even in some cases from hour to hour. At first this was very puzzling, and it was thought possible that such factors as food and water might be responsible. Experiments expressly devised for the purpose, however, showed that moderate starvation or thirst, followed by food or water, and moderate exercise, did not influence the erythrocyte count in any definite way.

When blood was taken simultaneously from the jugular vein and the ear, it was found that the count of the latter was almost invariably higher than that of the former, and that the difference was sometimes very great; the figure for the ear blood being subject to greatest variation. A few of the results obtained are given in Graph IV. Figures 1 to 4 give the data for horses which were given food while excited or immediately upon return from work, and then not disturbed at all excepting just at the time of bleeding. The data in figures 5 to 7 are those for animals that were taken away from food, and then excited by being threatened.

These results show that the two counts always converge when the animals are excited, and diverge most widely during digestion and rest, and that, as a rule, an increase in the count for ear blood is accompanied by a decrease in the count for jugular blood. Furthermore, in as short a time as 10 minutes the two counts can be made to agree by the mere process of threatening the horse. It is, therefore, not the food, as such, which causes this wide divergence between the two counts.

Graph IV.



Showing the relation between Ear and Jugular blood under various circumstances.
A—Jugular blood. B—Ear blood.

During the digestion most of the blood is diverted to the splanchnic areas, and peripheral circulation becomes slow. During excitement the blood pressure is raised, and the peripheral circulation is more vigorous. The two counts thus agree best when the circulation is vigorous, and least when the peripheral circulation is sluggish. It is thus the mechanical state of the circulation that influences the erythrocyte count, the distribution of the erythrocytes being most uniform when the circulation is very active. The concentration of the erythrocytes in the ear blood with a sluggish circulation is probably due to relative increase in lymph formation, and possibly in some instances to sedimentation. The daily and even the hourly variations in erythocyte count of jugular blood are now readily understood. They depend upon the mechanical state of the circulation rather than upon other factors.

Technique.

The technique employed may be summarised thus. Blood drawn from the jugular vein except when specially taken elsewhere, was collected in 10 c.c. bottles containing a measured adequate amount of sodium citrate solution. From this was determined: (a) The percentage volume of erythrocytes by centrifuging in specially prepared uniform tubes of 12 c.c. capacity, blown out slightly at the sealed end to facilitate rapid sedimentation. (b) Corpuscle count after diluting 1 in 200 with Hayem's fluid for erythrocytes, and 1 in 10 with 0·5 per cent. acetic acid for leucocytes, the Bürker chamber being used in both cases.

From numerous observations expressly designed to determine the degree of accuracy of methods in use, it was concluded that (a) the centrifuge gives very accurate and consistent data, (b) erythrocyte counts are liable to an error of up to 10 per cent. even with the improved Bürker chamber, (c) leucocyte counts are less liable to error.

The Leucocytes.

The physiology of these cells is not fully understood, but two functions may be mentioned as illustrating their importance; some of them act as "soldiers" and ingest bacteria that try to invade the organism while others ingest pieces of broken-down tissue and thus act as "scavengers" in the body.

The number of leucocytes per c.mm. of horse blood is very variable between individuals, the range so far observed being from about 5 to about 20 thousand. In the same individual the leucocyte count as a rule remains fairly constant over short periods of time, but sometimes varies quite considerably. In numerous experiments it was found impossible to influence the leucocyte count in a constant manner by such factors as moderate starvation or thirst, with food or water following. In one series of experiments, however, in which a horse was exercised, consistent

results were always obtained. The leucocyte count of jugular blood always increases during exercise, sometimes by over three thousand, whereas after exercise this hyperleucocytosis rapidly decreases, often giving rise to a hypoleucocytosis of short duration.

Leucocyte counts made from ear and jugular blood showed the interesting fact that the figure for the former is generally lower than that for the latter—the very reverse of what was found for erythrocytes. In the earlier work blood had always been obtained from the ear by making a large puncture, through which blood came freely without application of pressure. Small punctures were now made—so small that without pressure no blood flowed from the wound. The ear was then squeezed at the site of puncture, or at the base, and the blood so obtained subjected to count. The following figures were obtained:—

Blood obtained from ear by:—	Leucocyte count.
(1) Small puncture and apical pressure	14·3 thousand
(2) Small puncture and basal pressure	7·4 ,,
(3) Large puncture and no pressure	11·3 ,,
Jugular blood for comparison	12·4 ,,

These data demonstrate the tendency of the leucocytes to cling to surfaces, and this explains all the observed facts. That is, the increase in the number of leucocytes in jugular blood with exercise, and why the number in ear blood is generally lower than in jugular blood.

The microscopic characters of the leucocytes are brought out by staining blood films in certain ways, especially well by using Giemsa's stain. In films so stained at least five morphologically different leucocytes can be seen. These are conventionally named lymphocytes, monocytes, neutrophiles, eosinophiles and basophiles. By noting the nature of, say, 200 consecutive leucocytes in specially prepared stained films, one obtains the relative proportions in which these cells are present in the blood, and these figures, expressed as percentages, constitute the so-called "differential count of the leucocytes."

Smears eminently suitable for differential counts are made by a simple modification of Ehrlich's method. A small drop of blood is quickly transferred to a slide by means of a suitable platinum loop, and a cover slip, as broad as the slide, immediately lowered over it. The droplet at once spreads as a thin circular layer and on drawing the slip lengthwise over the slide all the blood is left upon the latter as a thin film in which the distribution of leucocytes is remarkably uniform. Such smears are eminently suitable for differential count after Giemsa staining in the usual way.

The differential counts obtained for equines are summarised in the following table:—

Adult Horses.	Lymphocytes.	Monocytes.	Neutrophiles.	Eosinophiles.	Basophiles.
Extreme variations	25-50	0-9	34-62	1-15	0-3
Average variations	30-45	2-8	45-60	3-9	0-3
(a) Average for "stabled" horses	36	4	54	5	1
(b) Average for "fast-working" horses ...	40	5	50	4	1
(c) Average for "other" horses	39	4	52	4	1
Average for groups (a), (b) and (c)	38	4	53	4	1
Adult mules, average ...	41	3	49	6	1
Adult donkeys, average	53	4	31	8	1

From this table it is seen that the differential count of the leucocytes is not influenced by work, as the averages for the horses in the three groups agree very closely. There is a marked difference between horses and donkeys, however, the figures for the neutrophiles and lymphocytes in the latter being practically the reverse of those in the former. Moreover, the donkey has an exceptionally high eosinophile count.

The differential count of the leucocytes of mules is approximately the same as that of horses.

In numerous experiments it was found impossible to influence the proportions of the various cells, excepting in the case of the eosinophiles. These cells were always increased in jugular blood when the animal was given a drink of water after a period of thirst. This eosinophilia is very transient, and disappears again in a few hours.

Mares just before and after foaling, and foals just after birth, showed a neutrophilia, that is, an increase in neutrophiles, in some instances up to 80 per cent. This, however, provided the animals remained healthy, had completely disappeared in two months.

Summary.

1. Erythrocyte counts of healthy horse blood are much increased by regular fast work.
2. Diurnal variations in erythrocyte count of horse blood are due to mechanical changes in the circulation influencing the distribution of the cells.
3. Leucocyte count is not influenced by regular exercises, but during exercise the count increases for jugular blood.
4. In taking blood by puncture, the technique is all important and, by varying this, widely different data may be obtained.
5. Comparative data for the blood of horses, donkeys and mules are offered.

OBSERVATIONS ON THE DEVELOPMENT OF THE NON-AQUATIC TADPOLE OF *ANHYDROPHRYNE RATTRAYI* HEWITT

BY

ERNEST WARREN, D.Sc. (Lond.),
Director of the Natal Museum, Pietermaritzburg.

With Plates II and III.

Read July 11, 1922.

Some years ago Dr. G. Rattray discovered the nests of a small frog, buried just below the surface of the ground in the moist forest and marsh-land of the Hogsback, Amatola Range. He observed that the tadpoles had no gills and drowned if placed in water. Some material was collected by Dr. Rattray and was sent to Mr. John Hewitt, Director of the Albany Museum, Grahamstown. In the "Records of the Albany Museum," Vol. III, Pt. 13, 1919, Mr. Hewitt published an account of the matter and also gave a description of the adult frog, referring it to a new genus and species.

The preserved eggs and embryos were kindly placed at my disposal by Mr. Hewitt, and subsequently Dr. Rattray was so good as to procure further material, since some important stages were absent from the first series.

The adult exhibits certain anatomical peculiarities, and the exact systematic position of the genus is somewhat obscure. In sending the material to me Mr. Hewitt remarked that a study of the embryology might throw some light on the affinities of the genus, but that in any case the mode of development of a non-aquatic tadpole should prove of interest.

The material which I have received is well preserved (strong formalin and Carnoy were employed), but it is deficient in the earlier stages. A series of preparations has been made, and some facts have been ascertained, but full details have not yet been worked out. In the present place reference will be made only to some of the broader features of the development.

In 1904 Miss Lilian V. Sampson published in "The American Journal of Anatomy," Vol. III, No. 4, 1904, a detailed study on the terrestrial development of the West Indian tree-frog *Hylodes martinicensis* (Bibr.) and, as far as I am aware, this is the only detailed paper that has appeared on the subject.

THE EGGS.

The rounded or slightly oval eggs are laid in a cluster of about twenty in a little chamber just below the surface of the ground and communicating with the exterior by a small hole in the roof. The eggs are large, and in my specimens range from 1·7 to 2·7 mm. in diameter. Each egg is enveloped by a stiff mucilaginous coat which is firmly adherent to the coats of the surrounding eggs. There is no perceptible vitelline membrane, so that on removing the mucilaginous coat the naked egg, which is very readily injured, is exposed. The eggs are yellowish white without a trace of pigmentation. In sections through non-segmented eggs I could detect only faint indications of a protoplasmic pole. The egg consists at first of a coarsely granular reticulum of protoplasm densely crowded with oval yolk-globules of large size (average maximum diameter about 12 μ). The periphery of the egg is occupied by a thin layer of protoplasm containing fewer yolk-globules, and these are of a smaller size.

SEGMENTATION AND EARLY STAGES.

With the available material a full account of the segmentation is not possible. The earliest stage present in the series shows four upper cell-masses or blastomeres elongated parallel to a vertical furrow and continuous at their periphery with the superficial protoplasmic layer surrounding the undivided yolk-mass below (Pl. II, fig. 1). These masses were moderately sharply cut off horizontally from the relatively huge mass of yolk, the vertical depth of the masses being only about one-sixth of the diameter of the egg (Fig. 1a). The blastomeres consist of denser protoplasm which, however, contains very numerous yolk-globules of about one-half of the diameter of the ordinary yolk-globules. The globules seem to have been reduced in size by being dissolved away superficially for the formation of the abundant protoplasm. The nuclei of these cells are large, oval, bladder-like structures with a minimum amount of chromatin. In none of the eggs was there any indication of vertical furrows dividing the yolk-mass beneath, although in *Hylodes martinicensis* Miss Sampson describes the occurrence of such furrows. On careful search I failed to find any nucleus at all in the yolk-mass, but with the excessive amount of yolk it is not possible to be entirely certain that none was present. At this stage segmentation is essentially meroblastic (Pl. II, figs. 1a, 1b).

The only other early stage of development present in the material shows a syncytial blastoderm of considerable depth with numerous large nuclei, enveloping less than half of the surface of the yolk-mass (Fig. 2). This syncytium is continuous with the superficial layer of protoplasm surrounding the yolk-mass (Fig. 2a). In this layer occurred a few large nuclei. The specimen showing this condition was obviously well preserved and the absence of cell outlines cannot, I think, be attributed to the action of the reagents employed. I consider it probable

that nuclei (n) have crept into the superficial protoplasmic layer from the syncytium in advance of the growing blastoderm. Nuclei (n.y.) appear to escape from the superficial protoplasmic layer and invade the neighbouring yolk-mass (Fig. 2b).

It is clear that the early stages are much modified by the presence of the excessive quantity of yolk. As far as the material goes it would appear that segmentation is confined to the formation of a few large, incompletely cut off cell-masses or blastomeres lying above the yolk-mass and communicating with it by the peripheral layer of protoplasm. Subsequently the nuclei divide without the separation of cells and the partially separated masses fuse and form a thick syncytium with numerous nuclei, and some of these creep into the peripheral protoplasm. Probably the superficial portion of the syncytium separates off as an ectoderm while the remainder becomes mesoderm. Thus, a massive blastoderm never completely surrounds the yolk as in the development of the common frog, but the general condition is very similar to that seen in the developing egg of the bird. With the available material it cannot be said whether a definite primitive streak is formed. The origin of the archenteron is also not exhibited, but in the earliest stages in which the gut is present the endoderm is so densely crowded with yolk and is so intimately associated with the yolk-mass that it is unlikely that it arises directly from the blastoderm, but it is doubtless differentiated from the mid-dorsal portion of the yolk-mass (Pl. III, fig. 2a).

The next stage which I possess shows the embryo with a well-developed neural tube, notochord and sub-notochordal rod, but the archenteron is still in a remarkably undifferentiated condition, with only a roof indistinctly marked off from the surrounding yolk The mesoderm has crept round from the region of the blastoderm and encloses the yolk with a very thin and scarcely continuous layer on the inside of the thin ectoderm layer. The ectoderm layer shows some signs of being divisible into an inner and outer layer.

Slightly later the whole yolk-mass splits up into large oval cells (Pl. III, fig. 2b), each bearing a large bladder-like nucleus. These nuclei appear to be derived from nuclei which have wandered into the yolk-mass from the thin, syncytial, superficial layer.

This cellular condition of the yolk lasts only a brief period, and very soon the majority, if not all, of the nuclei break down; the cells run together and the yolk-globules become almost free, for by this time the reticulum of protoplasm has become greatly reduced.

The Gut.

The archenteron becomes more especially differentiated at the anterior and posterior ends, and takes a straight course throughout the length of the embryo. In the middle region it is only indistinctly separable from the yolk. Anteriorly it expands considerably to form the pharynx region, while posteriorly it also

expands to some extent (Pl. III, figs. 1 and 2). A shallow stomodæal pit arises immediately under the fore-brain. A proctodæum is not formed until later. The fore-gut of the embryo sends downwards a diverticulum (*d.f.g.*) into the yolk, and from the front of this a prominent anterior cæcum arises which is the beginning of the liver (*h*, *h.c.*)

The vertical diverticulum grows and bends over to the right side of the middle line. It gradually becomes U-shaped, growing at the expense of the yolk. A short portion of the middle region of the archenteron tube disappears (fig. 2, *a*), and a little later the front end of the posterior portion of the archenteron becomes deflected to the left and retains a superficial dorsal position. Thus the gut now consists of a fore and hind-gut which are only connected together by the non-cellular yolk-mass (Pl. III, fig. 3, *a.f.g.*, *a.h.g.*).

Growth at the attached or inner ends of the two portions of the gut continues, the hind-gut grows forward and sharply dips down ventrally at the front surface of the yolk-mass. The growing end of the U-shaped fore-gut passes up into a dorsal position. Also, the posterior end of the hind-gut grows backwards so as to project considerably behind the yolk-mass (Pl. III, fig. 4). This is the condition of the gut in a tadpole which has already grown a long tail.

In the next stage shown in the series both fore and hind-limbs are conspicuous, and the tail has been reduced to a small rudiment. Here the gut is still quite simple, but the whole of it has undergone a profound modification. The fore and hind-gut have become continuous, incorporating the whole of the yolk in the swollen cells. The hind-gut has become stouter and has shortened very greatly (Pl. III, fig. 5). From this simple condition the adult configuration is derived, where the parts are relatively much longer (Fig. 6).

Ordinary tadpoles have relatively a very much longer gut than in the adult. In the present case, we have a great shortening taking place at the time of metamorphosis, but there is a subsequent elongation and remodelling of the whole alimentary canal. It has been shown by Bataillon* by direct experiments on living tadpoles that the shortening of the intestine at metamorphosis involves the whole length and not merely some special portion of it; but here there is a profound remodelling of the whole gut after the shortening has occurred.

There is no trace of external gills, but there is some indication of gill-pouches in the lateral walls of the embryonic pharynx. I could detect no gill-slit grooves in the external epidermis.

Immediately behind the gill-slit region of the pharynx, the alimentary canal early loses its lumen and becomes solid. A lumen gradually becomes reformed after the fore-limbs have appeared on the outside.

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* Boulenger, G. A.—" The Tailless Batrachians of Europe," Part I, p. 97, Ray Society, London, 1897.

THE LIMBS.

The hind-limbs appear as buds extremely early in development and arise as soon as the tail begins to be formed (Pl. II, figs. 3, 4). The fore-limbs appear a little later as slight knobs between the head and yolk-mass. At first these knobs are entirely exposed. Very soon, however, a fold of epidermis begins to grow over them from behind, and before long each of the fore-limbs is completely enclosed by a separate fold. Curiously enough, these folds are not back-growths of the epidermis from the hyoid region. The folds arise behind the head on each side of the middle line. They grow obliquely forwards and downwards; they cover the fore-limb buds and fuse on to the epidermis in front of and below the buds. It is not possible to regard these folds as non-homologous with a true opercular fold, but the line of origin of the fold has been shifted away from its typical position. In the development of *Hylodes martinicensis* Miss Sampson described a very closely similar condition.

The first two gill-slit pouches of the pharynx come into contact with the epidermal lining of the atrial cavity, but no trace of perforation appears. The opercular or atrial chambers of the two sides remain widely separate and quite distinct from each other. Perforation of the operculum by the fore-limbs occurs late in the metamorphosis.

LARVAL SUCKER.

There is no sub-oral sucker at any period, and I could detect no trace of even a rudiment of the structure.

TAIL.

The tail is long and is provided with mid-dorsal and ventral membranes. It is moderately vascular, but not appreciably more so than in an aquatic tadpole. Thus the terrestrial mode of life has not had any marked modifying influence on the tail. In *Hylodes martinicensis*, on the other hand, the tail is short and flattened, and according to Miss Sampson it is very vascular and is used for aërial respiration.

SKELETON.

The sacral diapophyses are distally dilated in the adult, while in the minute frog with a short tail the cartilaginous diapophyses are thick but more or less cylindrical, and they exhibit no appreciable terminal dilatation. The ilium cartilages are ventral to the sacral diapophyses, and their free ends extend considerably beyond the sacrum and reach the level of the small diapophyses of the vertebra in front. Mr. Hewitt informs me that such a forward extension of the ilia is not obvious in the adult. I am not aware whether a similar condition occurs in developing *Rana;* but judging from certain good drawings of adult anuran skeletons in Peters' and Boulenger's publications there is a distinct tendency for the ilium to extend somewhat considerably beyond

the sacral diapophyses. For example, in Boulenger's sketch of the skeleton of *Alytes obstetricans*† the ends of the ilia reach the level of the transverse processes of the vertebra in front of the sacrum. This stretching forward of the ilium is interesting in connection with the view that the sacrum has advanced forwards during the phylogeny of the *Anura;* and in existing forms the sacrum may consist of one, or more, of vertebræ X—VI.

In the adult there is a firmisternous pectoral girdle, clavicles absent and coracoids widely expanded ventrally. In the tadpole the girdle arises in a firmisternous condition and the coracoids are broadened ventrally. In the large tadpole there is a well-marked pre-coracoid cartilage, but in the transforming frog it is already becoming greatly attenuated.

Dimorphism of the Eggs and Embryos.

A careful examination of all the eggs and embryos disclosed the fact that they could be grouped into two series of about equal numbers. In the one series the diameters of the eggs ranged from about 1·7 to 2·2 mm. and in the other from about 2·4 to 2·7 mm., the average diameters being about 2·0 and 2·6 mm. respectively, and the cubic content being in the ratio of 1:2. These eggs developed into small and large tadpoles in which there was naturally a very marked difference in the size of the yolk-mass. In the case of the developing tadpole of the small-sized series the tail very early projects straight out from the yolk-mass in line with the long axis of the embryo, while in the large-sized series the tail grows round the yolk-mass and does not straighten out until much later in development (Pl. II, figs. 3, 4). Taking the development of the hind limbs as a criterion of age, and comparing the tadpoles of similar ages in the two series, it is found that there is a marked difference in the tails. In the smaller tadpoles the tail is relatively deeper dorso-ventrally and the swimming membranes wider than in the larger tadpoles. It would appear that a more normally developed swimming membrane is associated with a less excessive quantity of yolk. Since large and small eggs occurred in the same clutch, and the two sizes were approximately equal in number in the whole series, it would appear very probable that the differences are associated with sex, and that the small eggs develop into males and the large eggs into females. On first observing the difference in the tadpoles it was not realised that marked variation in the size of the eggs occurred in the same clutch, and I consulted Mr. Hewitt as to the possibility of the eggs being mixed and belonging to two allied species. Mr. Hewitt re-examined his series of specimens and came to the conclusion that only one species was present. That the dimorphism of the eggs and tadpoles is associated with sex is rendered more probable by the fact that there is an unusual amount of difference between the adult male and female. The males tend to be smaller, they

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† Boulenger, G. A.—l.c., p. 167.

have a more pointed snout and are differently coloured. The interesting point to note is the apparent pre-determination of sex in the egg.

According to Dr. Emil Witschi* differences may be detected very early indeed in the development of the testis and ovary. Notwithstanding these facts, there would appear to be no doubt that semi-starved tadpoles tend to become males, and very possibly in the case of *Anhydrophryne* if a newly transformed frog from a large egg received only a minimum amount of food it would become a male, the female tendency being overcome by the reduced metabolism of semi-starvation. It would be interesting to know whether the smaller members of the egg-clutches of egg-laying animals tend to become males when other factors are equal. In this connection it may be remarked that in the case of Hydroids which carry both male and female gonangia or sporosacs on the same colony, the male gonangia always tend to occur in those places of the colony where there would be a less abundant supply of nutritive substances.

Summary.

1. Segmentation meroblastic, blastoderm syncytial, nuclei creep down into superficial protoplasmic layer surrounding the yolk-mass to form enveloping ectoderm. Inner portion of thick syncytial blastoderm becomes mesoderm, nuclei from enveloping layer invade the yolk-mass, and at a comparatively late period when neural tube, notochord and archenteron are established the whole yolk-mass breaks up for a brief period into moderate-sized cells. The cause of this peculiar mode of early development must undoubtedly be referred to the presence of the excessive quantity of heavy, intractable yolk.

2. From the fact that there are two sizes of eggs which undergo slightly different modes of development it is concluded that under normal conditions of growth sex is predetermined in the egg.

3. As far as the observations have been conducted the general developmental history of the tadpole does not promise to afford any very great assistance in deciding on the systematic position of *Anhydrophryne*, but this is perhaps partly due to the fact that the detailed comparative embryology of the different divisions of the *Anura* is very incompletely known The general development of *Anhydrophryne* is clearly much abbreviated, but in only a few characters so far studied can the development be said to be direct There is a well-developed tail, although it is never used for swimming, while on the other hand there is a complete absence of gills, gill-slits, suboral sucker and beak.

4. Although the typical spiral intestine of ordinary tadpoles is never formed, and the gut is never greatly elongated, yet the development of the gut is very far from being direct, for when metamorphosis is proceeding and the tail is shrinking, every part of the embryonic gut becomes modified to a surprising extent.

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* Witschi, Emil.—"Development of Gonads and Transformation of Sex in the Frog." *The American Naturalist*, Vol. LV, No. 641, p. 529, 1921.

5. Hewitt refers *Anhydrophryne*, which has a toothed upper jaw, to the *Ranidæ*, and in some respects it resembles the genus *Cacosternum* which is also toothed, and perhaps should be regarded as a Ranid, although it is usually grouped in the *Engystomatidæ* in which the upper jaw is typically toothless. In both genera there is a firmisternous pectoral girdle in which there is an expanded coracoid but no clavicle or precoracoid. In the embryo of *Anhydrophryne* there is a well-marked precoracoid cartilage, but probably such is also the case in the tadpole of *Cacosternum*.

6. In association with the shortening of the vertebral column in the *Anura* there appears to be a general tendency for the ilia to extend anteriorly beyond the sacral vertebra. This condition is well-marked in the tadpole of *Anhydrophryne* where the ends of the ilia extend as far forwards as the level of the diapophyses of the vertebra in front.

7. The sacral diapophyses of adult *Anhydrophryne* are dilated distally, but are not relatively so broad as in *Cacosternum*. In the embryo of *Anhydrophryne* the sacral diapophyses are large and almost cylindrical and Ranid in character, but before any conclusion can be drawn from this fact it would be necessary to know the condition of these structures in the tadpoles of other genera. The evidence of the present investigation certainly supports the view that the characters of tadpoles in general are very largely adaptive, and consequently great caution is necessary in drawing phylogenetic conclusions.

EXPLANATION OF PLATES.

Plate II.

Fig. 1.—Segmenting egg of *Anhydrophryne rattrayi*. View from above showing four incompletely separated blastomeres. × 10.

Fig. 1a.—Vertical section of segmenting egg showing undivided yolk-mass below, with a peripheral layer of protoplasm continuous with the blastomeres above, which contain numerous half-sized yolk-globules. × 60.

Fig. 1b.—Upper and lower portions of a vertical section at a stage similar to that of fig. 1a, showing cleft-cavity and grooves of incompletely separated blastomeres; also, coarsely granular reticulum of protoplasm between yolk-globules, and superficial layer of protoplasm around yolk-mass with smaller yolk-globules. × 300.

Fig. 2.—Ovum with shield-shaped blastoderm. × 10.

Fig. 2a.—Vertical section in long-axis of blastoderm. Blastoderm consists of a thick, richly nucleated syncytial layer which is growing along the margins and is continuous with the peripheral layer of protoplasm surrounding the undivided yolk-mass below. It would appear that nuclei (n) migrate from the blastodermal syncytium into this superficial layer, and also into the neighbouring yolk (n.y.). In the lower quadrant it is supposed that the yolk-globules have been removed in order to display the protoplasmic reticulum. × 30.

Fig. 2b.—Upper and lower portions of a vertical section (cf. fig. 2a) showing syncytial blastoderm with scattered nuclei, vacuole-spaces and yolk-globules of small size. In lower portion a nucleus is seen in the superficial protoplasm and also one in the periphery of the yolk-mass. × 300.

Fig. 3.—A small-sized egg (probably male) with embryo. The beginnings of fore- and hind-limbs are visible. The fore-limbs are as yet quite exposed and uncovered by any fold. In the case of these small eggs the tail projects straight backwards from a very early stage. × 10.

Fig. 3a.—A small tadpole (probably male). Note the shape and expansion of median swimming membranes of tail and compare with those of the large tadpole, fig. 4a. × 10.

Fig. 4.—A large-sized egg (probably female) with embryo. The beginnings of the fore-limbs are covered by a forwardly growing epidermal fold (f.) which must be regarded as an opercular fold whose line of origin has been shifted from the normal position on the hyoid arch. In the case of these large eggs the tail grows coiled against the yolk-mass, and straightening does not occur until relatively late (cf. fig. 3). × 10.

Fig. 4a.—A large tadpole (probably female). Compare with small tadpole, fig. 3a, and note relatively longer tail and reduced swimming membranes. × 10.

Plate III.

Figs. 1—5 are drawings of models of the gut, which have been prepared from microscopical serial sections.

Fig. 1.—Side view of gut and yolk-mass of early embryo when tail and hind-limbs are only just appearing: *a.* Archenteron, *d.f.g.* Descending portion of fore-gut, *h.c.* Hepatic diverticulum, *p.* Pharynx. × 20.

Fig. 2.—View from above of gut and yolk-mass (cf. fig. 1). *h.* Hepatic diverticulum. × 20.

Fig. 2a.—Transverse section through sub-notochordal rod, archenteron (*a*) and unsegmented yolk-mass (*u.v.*). × 75.

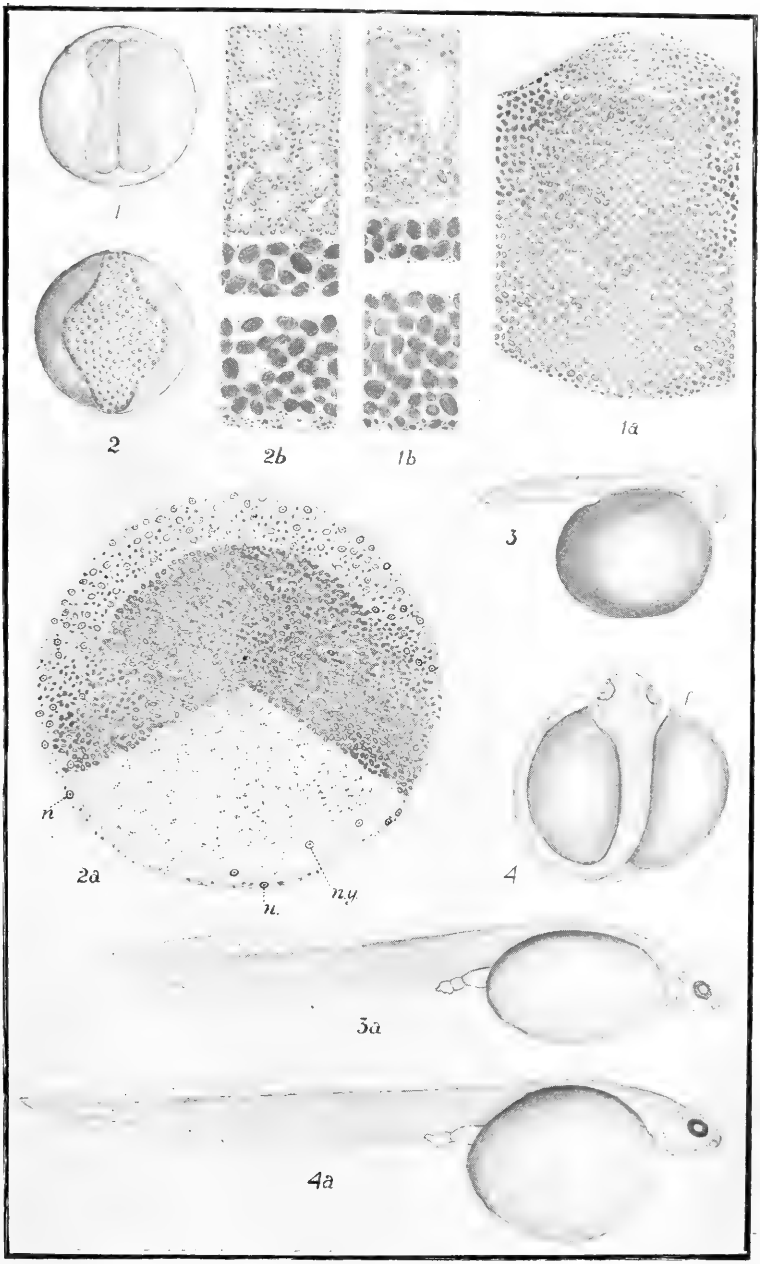
Fig. 2b.—Section through descending portion of fore-gut (*d.f.g.*) which is being differentiated out of yolk. Embryo is a little older than in fig. 2a and the whole yolk has rapidly broken up into large oval separated cells (*y.c.*) crowded with yolk-globules. This cellular condition of the yolk is very transient; very soon many of the large nuclei break down and an apparently continuous yolk-mass again results. × 60.

Fig. 3.—View from above, showing attachment of fore-gut (*a.f.g.*) and of hind-gut (*a.h.g.*) to the yolk-mass, the middle region of the archenteron tube has disappeared. × 20.

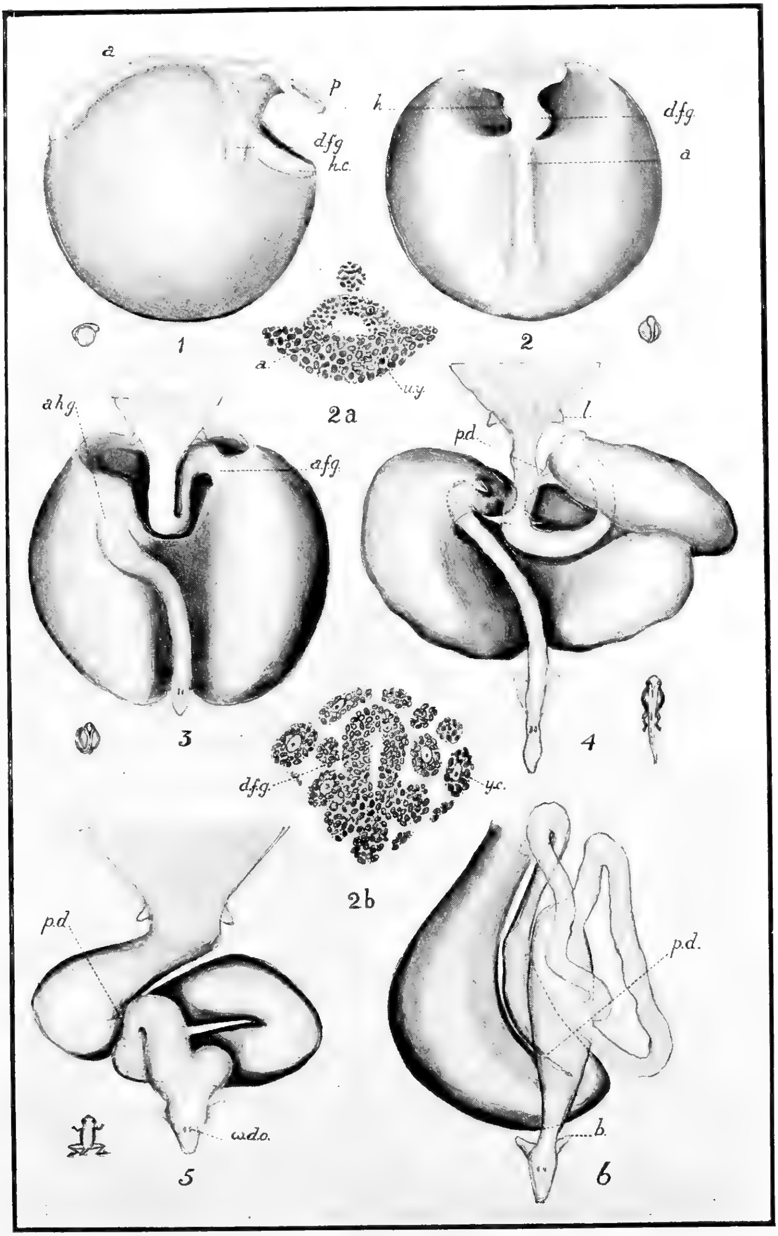
Fig. 4.—Later stage. Differentiation at the attachments of the fore- and hind-guts to the yolk-mass has progressed. At the same time the yolk-mass is endowed with vitality and is being modelled as a whole into a thick, crude spiral yolk-band passing ventrally, and connecting the two ends of the more perfectly formed gut. *p.d.* marks the position of the attachment of the pancreatic duct to the part of the yolk-band which will be converted into the hinder portion of the duodenum. *l.* Lung sac. × 20.

Fig. 5.—Gut of metamorphosing frog in which the tail has nearly disappeared. The whole of the gut has undergone great modification since the tadpole condition seen in fig. 4. The well-formed portions of fore- and hind-gut of fig. 4, which appeared to be definitive in nature have shortened and thickened very greatly, and the yolk-band has been reduced to a simple U-shaped loop extending horizontally. *w.d.o.* Wolffian duct openings. × 20.

Fig. 6.—Dorsal view of gut of adult frog given for comparison with fig. 5. It will be noticed that relatively the gut has elongated considerably. The position of the opening of the pancreatic duct (*p.d.*) in figs. 4, 5 and 6 gives some idea of the fundamental re-modellings and transformations of the whole of the gut in the later stages of development. *b.* Bladder. × 4.



DEVELOPMENT OF ANHYDROPHRYNE RATTRAYI.



DEVELOPMENT OF ANHYDROPHRYNE RATTRAYI.

To face page 262.

THE ORIGIN OF FEATHERS FROM THE SCALES OF REPTILES.

BY

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With Plates IV and V.

Read July 11, 1922.

One of the many problems still confronting zoologists is that of the origin of feathers as a covering of birds and as a means of flight. No structures at all resembling them are to be found in any other group of animals to indicate the course along which they have evolved. Since the days of Huxley, however, very little doubt has remained that, in some way, they represent the scales of reptiles. Professor Huxley first showed that in many respects the scaly, cold-blooded reptile is closely related to the feathered, hot-blooded bird, and subsequent investigations have but served to support the conclusion. From this the view naturally followed that the feathers of birds, however different they may at first sight appear, have in some manner replaced the scales of reptiles.

It is well known that scales and feathers are much alike in the early stages of their development, both being formed as upgrowths of the epidermis followed by the nutritive dermis; and it has been generally assumed that, by some means, scales have, in the course of evolution, become frayed out until they have taken on the character of feathers. Very little real evidence in support of the theory has, however, been forthcoming, much less of how the fraying-out first took place. One of the latest contributions is that by Professor J. Cossar Ewart,* who contends that, while feathers are closely associated with scales in their origin, they are developed independently from the skin under the scales, and not by a splitting of the scales or from fragments of the scales.

Since birds are held to have evolved from reptiles, it follows that the ancestors of birds must have been entirely covered with scales, as are all reptiles at the present day. This scaly covering has largely disappeared and has been replaced by feathers in all modern birds, but relics of the former generally persist on the legs and toes. It would, therefore, be reasonable to expect that these surviving scales might, in some instances, indicate how

* *Proc. Zoological Soc.*, Lond., 1921.

the passage from scale to feather has been accomplished. As a matter of fact, we find feathers intimately associated with scales on the legs and toes of a great number of birds, including many breeds of poultry, domesticated pigeons, and most birds of prey. Certain conditions recently observed in ostrich chicks, at about the time of hatching, appear to be peculiarly convincing as to the real relationship of scales and feathers, and to afford a true key to the problem.

The ostrich, as is well known, has a row of large, quadrilateral, over-lapping scales passing down the front of the tarsus and continued over the big toe. In addition, the general surface of the tarsus at the sides and behind is covered with very small, polygonal scales, which are continued for some distance above the ankle, and cease where the leg feathers begin in the chick. At the place of transition, where the scales, as it were, are about to pass over into the feathered part of the skin, the former actually appear to give rise to feathers; we have, in fact, the appearance of feathers growing directly out of the scales.

The scale-feathers are to be found on ostrich chicks only for a week or two before and after hatching, and are more conspicuous on some individuals than on others. Before the chick leaves the egg they are in the form of filaments of different size, but after hatching, the larger ones open out and resemble the down which covers the chick generally. The greater number of the filaments, however, fail to expand, and the feather germ atrophies within a week or so, when the expanded feathers also fall out. The down feathers of the ostrich are not of the simple, primitive nature of the first feathers of birds such as the penguin. They already consist of a tuft of barbs bearing small barbules, and three to five of the former are longer than the others and constitute the dorsal shaft, while the smaller represent the ventral aftershaft. Since despite this structural complexity they are still associated with scales, it is reasonable to suppose that the same relationship would be all the more likely to hold at the earlier stages of their evolution.

The appearance under a low power of the microscope of a portion of the skin, just before the scales leave off, is represented in Pl. IV, Fig. 1. Each polygonal area represents one of the small leg-scales which join one another at their edges. From the lower border of each projects a blunt upgrowth or papilla, which partly overlaps the scale below it. Microscopical sections have been made of these, and their internal structure proves that they are true feathers at a late stage of development. The conditions a little higher up the leg, where the scales actually disappear, are shown in Pl. IV, Fig. 2. Here the scales occur only in the lower part of the drawing, while above are to be seen unexpanded feather filaments of different sizes and irregularly arranged. These arise from the scaleless part of the skin, and are exactly similar to those which grow from the scales. On Pl. V, Fig. 3, is represented the appearance in an ostrich chick about a fortnight after hatching. Four of the larger filaments have now opened out, and form small tufts of barbs with barbules along each side,

and are like the down feathers which cover the body and wings of the chick, only less in size. The smaller filaments on the other scales have not expanded, but have already begun to atrophy and soon disappear, while the expanded tufts drop out or break away. No trace of the scale-feathers is therefore to be found in chicks after they are about a month old.

Vertical sections (Pl. V, Figs. 4 and 5) show that the feather filaments are direct upgrowths of the flat scales; the different layers of the epidermis of the feather are continuous with and of the same character as those of the scale, and the underlying dermis of the one is inseparable from that of the other. Later, the feather filament grows down into the skin, forming a socket or follicle, and then presents the appearance of growing out through a perforation of the scale, though no break in the continuity of the epidermis occurs (Fig. 5).

Similar relationships of scale and feather have been found to hold in the feathered legs of poultry and pigeons. The mature feather appears as an outgrowth through the scale. Where, as in the case of the barn owl (*Strix flammea*), feathers appear as if growing out from under the scales, it is manifest that they have arisen from near the margin of the scales, and that their later downgrowth is a secondary relationship, as in feathers generally.

Discussion.

The details briefly given are restricted to the actual appearances as regards the origin and relationships of feathers to scales in the ostrich chick. Where, however, we attempt an interpretation of the relationships, two wholly divergent views have to be considered. First, we may hold that, in the course of evolution, feathers have originated directly from scales; that scales have, as it were, become transformed into feathers; that the feathers of birds are nothing more than the modified, frayed-out scales of reptiles. Second, we may regard feathers as wholly new and independent formations, quite apart from scales in their origin, but for their expression necessarily making use of the same germinal layers as scales.

The first view is that which has hitherto prevailed among zoologists, and is conformable with the usual interpretations adopted in studies of homology and comparative morphology, upon the foundations of which the theory of organic evolution has been largely erected. Homology attempts to establish the similarity in origin and nature of structures seemingly diverse. It proceeds on the assumption that during the course of evolution structures have gradually undergone certain divergences and transformations, but yet remain the same in their fundamental nature. Hitherto, scarcely anyone has questioned that feathers have evolved from scales. The only divergence has been as to the process by which the change has been accomplished; but the details presented by the ostrich would appear to leave no doubt as to this. Following the ordinary interpretations of homology, it would be accepted that scales have become transformed into

feathers largely by a complicated series of incisions of an upgrowth from the scale. Further, it is possible to show that the scale upgrowth which becomes changed into a feather is really comparable with the overlap found in the imbricating scales of many lizards and snakes; also that in its formation the feather has a dorso-ventrality comparable with that of the overlap of scales, the outer, dorsal aspect of the scale representing the shaft of the feather, and the under ventral surface the after-shaft of the feather. This homology established, it is also easy to show that the overlap of scales is comparable with claws and nails, and that the unguis of the latter represents the shaft of feathers, and the sub-unguis the after-shaft. Longitudinal invasions of the dermis into the epidermis take place in all of them, though they are sufficiently deep to result in the splitting or fraying of the horny material only in the case of feather formation.

The second view is that which we seem compelled to accept on a strict adherence to the factorial hypothesis, upon which modern Mendelism is based. This assumes that every character in the body has discrete representation in the germ plasm; that new characters appear as a result of changes in the germ plasm; that they are mutations or saltations, not a gradual transition from something previously existing to something new. In so far, then, as the relationship of the feather to the scale in the ostrich really represents what has occurred in the evolution of feathers, we are to regard the feather as a wholly new structure which has appeared in association with a scale, but that in its origin and nature it is something apart from and independent of it. It is not that the scale has been transformed into a feather. There is no such thing as homology between the scale and the feather, as the term is usually employed. Each has separate and independent representation in the germ plasm. Thus, instead of regarding feathers as homologous with the overlap of the scales of reptiles, and also with the claws of reptiles and birds and the nails of mammals, they are to be considered as distinct mutations which have appeared in the course of evolution of birds from reptiles, and their association with scales and resemblances to other horny structures are altogether incidental. Coincident with the appearance of feathers we have a disappearance of scales, either by loss of factors or their inhibition, apart from the relics on the legs and toes where the two continue together.

It is manifest that the application of the conception of the discreteness of characters in this fashion raises the whole question as to the meaning of the comparisons instituted in studies of homology and comparative morphology. According to the factorial view, a modification of an existing structure by the addition of a new feature is not a transformation of the old, but represents something wholly new. Homology, however, is based upon the idea of transformation; a structure having certain characters has been changed into another with other characters, but without losing its identity. We may take, for example, the visceral arches of vertebrates. In comparative anatomy we attempt to homologise the cartilaginous arches in such a form

as the dogfish with the bony arches of the teleost, and it is then sought to compare these with diverse bony structures in the amphibian, bird and mammal, the details of which are familiar to every student of the vertebrates. We know that the cartilage has become replaced, and assume that it is represented by the bones of the teleost, and that these in their turn have become transformed into bones of different form in the amphibian, reptile, bird and mammal without loss of identity. Thus, the pterygoid is supposed to represent the same bone throughout the series, whatever be its form, and also to be represented by a part of the upper jaw of the cartilaginous fish. With some show of justification we can point to the fact that at their earliest stage of development, the cartilaginous stage, the arches of all vertebrates are practically alike, and then assume that the bones derived from these and occupying the same relationships correspond throughout the vertebrate series.

On the factorial hypothesis, however, we can just as well regard the bones of the teleost arches as entirely new structures which replace the earlier cartilage, represented, as they must be, by new factors in the germ plasm. It is true they appear to be a transformation of the latter, but this has no further meaning than, on the same hypothesis, has the replacement of scales by feathers in the ostrich. They are not homologous structures, though they occur in the same position and have essentially the same relationships, if they can be held to be the expression of germinal factorial differences. Similarly with the modifications of the visceral arches in the higher classes of the vertebrates. The bones which replace the early cartilage are not necessarily the same as those replacing it in the teleost; unless they represent modifications due to different somatic influences they are new formations with their own germinal representation distinct from that in teleosts. If each change in a structural part indicates a germinal change, and takes place apart from what has gone before, the term homology as usually understood has no application; each modification represents a new character and is only incidentally associated with the old.

We can only accept gradual morphological transformation as a basis of evolution if we agree with Warren* that factors themselves undergo change, as he concludes from his experiments on the crossing of foxgloves, or accept the hormonic hypothesis of Cunningham,† which attempts to show how a character may arise or be modified by the production of internal secretions. Both these afford a suggestion as to how the old may be gradually transformed into the new, and thereby give us a basis for comparative morphology.

If, then, we follow strict Mendelian principles, we must conclude that feathers in birds have originated *de novo* from independent factorial germinal changes, and that their association with scales is only incidental; whereas, if we apply the recognised principles of homology, we must hold that feathers have evolved

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* *South African Journal of Science*, vol. xviii, 1922.

† "Hormones and Heredity," London, 1921.

through the gradual transformation of reptilian scales by a complicated splitting of horny upgrowths. In the present chaotic state of evolutionary theory we are only justified in presenting the two issues involved.

EXPLANATION OF PLATES.

Plate IV.

Fig. 1.—Portion of skin from fore-leg of ostrich chick about the time of hatching. The skin is here covered with small, flat polygonal scales, and from the lower border of each arises a short upgrowth or papilla, which represents an early stage in the development of a feather.

Fig. 2.—Portion of skin from a little higher up the leg than that shown in Fig. 1. The scales, each with a feather papilla, are present in the lower part, but disappear above, where longer feather filaments occur, which, on opening out, give rise to the down which covers the upper part of the leg of the ostrich chick. Two of the longer filaments have been plucked out to show more clearly the incipient plumulæ (filoplumes) around their base.

Plate V.

Fig. 3.—Scales from skin of ostrich chick, about two weeks after hatching. Four of the larger feather filaments have opened out into small, tuft-like feathers, composed of barbs with barbules, resembling the down which covers the young chick. The feather papillæ on the other scales have shrunken, and soon completely atrophy; the scale-feathers also fall away.

Fig. 4.—Section of skin of ostrich chick, in about the same condition as that shown in surface view in Fig. 1. The section passes through a number of scales (*sc.*), and in three of them a feather papilla (*sfp.*) is included. The feather at this early stage appears as a definite upgrowth from the hind part of a scale, the epidermis (*ep.*) being followed by the underlying dermis (*der.*).

Fig. 5.—Section through a feather filament showing it to be an outgrowth from a scale. The epidermis of the scale is made up of several layers of cells. The lowermost is the formative layer or Malpighian layer (*fl.*); its cells are active and continually dividing, adding others to the layers above. The second is the intermediate cell-layer (*int. l.*), while the third is the sheath or horny layer (*sh. l.*), in which cells are formed into horny material. The epitrichium (*ept.*) is the outermost layer of the epidermis. The same layers are continued from the scale into the feather and form the various parts of the feather, such as barbs, barbules and feather-sheath. The middle pith or pulp of the feather (*pt.*), which nourishes the feather during its growth, is a continuation of the dermis (*der.*), the under-layer of the skin. The lower part of the feather grows downwards into the dermis, forming a follicle or socket, and thus gives the appearance of the feather growing through the scale.

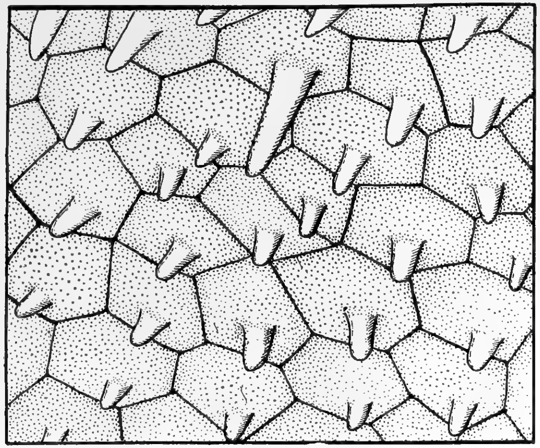

Fig. 1.

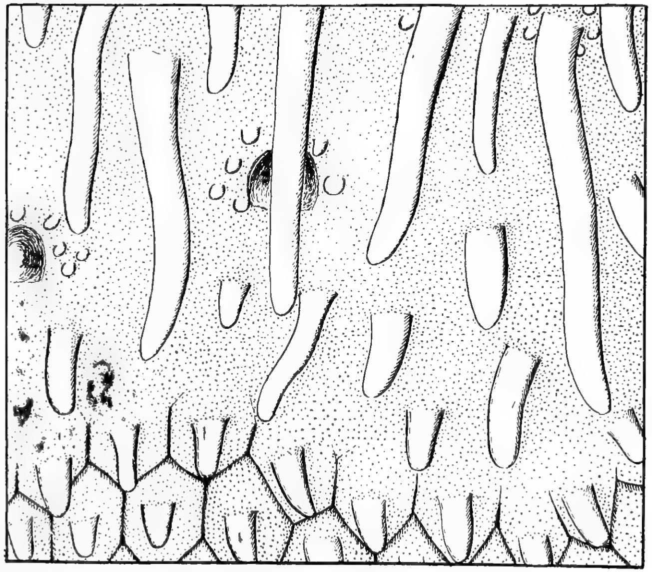

Fig. 2.

ORIGIN OF FEATHERS FROM SCALES.

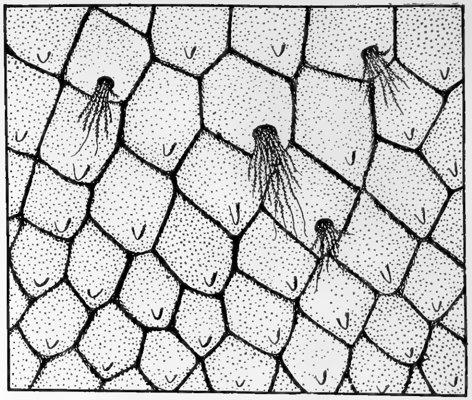

Fig. 3.

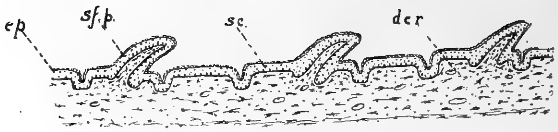

Fig. 4.

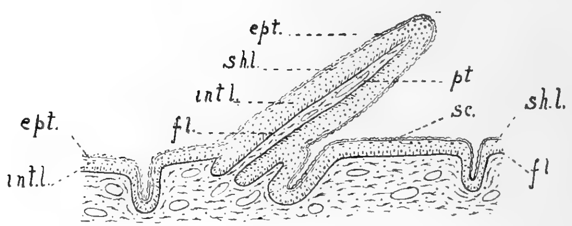

Fig 5.

ORIGIN OF FEATHERS FROM SCALES.

To face page 268.

DEGENERATION IN THE LIMBS OF SOUTH AFRICAN SERPENTIFORM LIZARDS (CHAMAESAURA).

BY

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AND

R. ESSEX, B.Sc.

With 4 Text Figures.

Read July 11, 1922.

The South African genus of lizards, *Chamaesaura*, comprises three species, in each of which the limbs are greatly reduced and the body is snake-like in form, due to an elongation of the tail region. The limb degeneration has proceeded to a different degree in each of the species. Thus in *C. aenea* both pairs of limbs are present, but are greatly reduced in size in comparison with ordinary lizards, and the normal five-clawed digits occur; in *C. anguina* both pairs are also present, but are styliform and barely divided into two minutely clawed digits; while in *C. macrolepis* the fore-limbs are altogether absent, and the hind-limbs are styliform and undivided. In all three the limbs lie closely appressed to the sides and, with the possible exception of *C. aenea*, are manifestly too weak to be of much service in progression. The purpose of the present investigation is to determine the method according to which the degeneration of the limbs has taken place, as possibly throwing some light upon the manner in which retrogressive evolution proceeds.

We are under obligation for specimens to Mr. J. Hewitt, B.A., Director of the Albany Museum; Dr. E. Warren, Director of the Pietermaritzburg Museum; Mr. C. J. Swierstra, Director of the Pretoria Museum; and Mr. F. W. FitzSimons, Director of the Museum, Port Elizabeth.

The method pursued in each case has been to macerate the specimens for a time, either in water or in weak caustic potash, and then to remove the limbs. By careful manipulation under the dissecting microscope it was possible to dissect away the covering of lanceolate keeled scales and the greater part of the underlying muscle, clearing afterwards in a mixture of glycerine and alcohol. Some of the limbs have been stained in picric acid after dissection, cleared in xylol and permanently mounted.

CHAMAESAURA AENEA.

In this species the two pairs of limbs have merely undergone reduction in size, without the loss of any of the constituent parts. From their attachment to the body to the tip of the longest digit, the fore-limbs vary in length from 9 to 11 mm. and the

hind-limbs from 14 to 16 mm. The usual lacertilian carpal and tarsal bones occur, as well as the normal number of metacarpals and metatarsals, and the phalangeal formula is that characteristic of reptiles, namely, 2, 3, 4, 5, 3, each digit terminating in a well-defined claw (Fig. 1). Certain variations in the number of phalanges have been met with, but not more than may well be regarded as within the limits of fluctuating variability, without any suggestion of orderly degeneration.

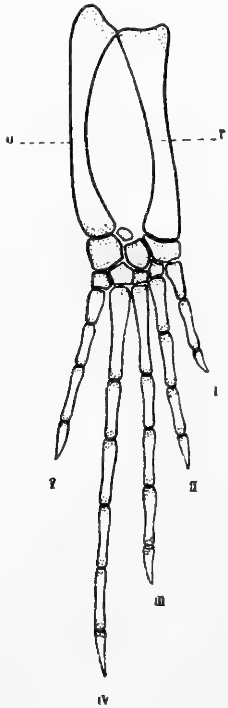

FIG. 1.—Fore-limb of *Chamaesaura aenea*. *r.* radius, *u.* ulna, I to V, digits.

CHAMAESAURA ANGUINA.

The limbs here present a very different outward appearance from those of *C. aenea*. They are smaller in proportion to the body, the fore-limbs being about 6 mm. in length and the hind-limbs about 8 mm. They are flattened and styliform, with but a slight bend at the elbow and knee joints. Sometimes a hint is afforded of a separation into two digits, but usually the limb terminates in a single minute claw.

Dissection reveals a marked reduction in both fore- and hind-limbs, but with considerable individual variation, a contrast to the general fixity found to characterise the previous species (Figs. 2 and 3).

In the *fore-limb* (Fig. 2) only two digits are present. Without intermediate stages for comparison, it is impossible to be certain which of the normal five digits these represent. From their general relationships, however, they appear to be the second and third of the series, and as such they are tentatively regarded. The number of phalanges is reduced either to one or two on the second digit, and to three on the third digit. In the carpus the radiale and ulnare are distinct bones and the distal row is reduced to three. These may possibly represent the carpalia of digits 2, 3 and 4, though it is more likely from comparison with corresponding stages in the hind-limb that the outer, post-axial represents the reduced fourth metacarpal.

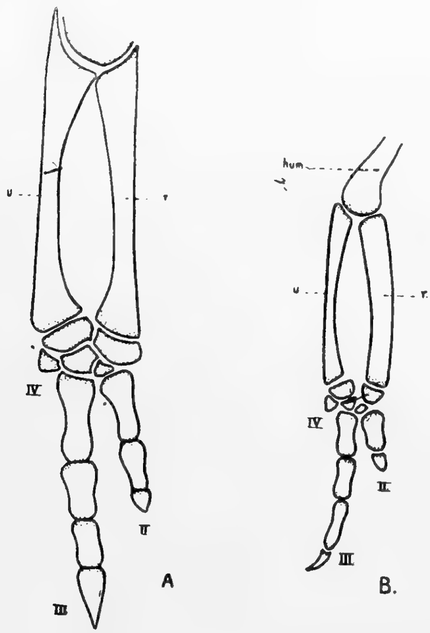

FIG. 2.—Fore-limbs of *Chamaesaura anguina*.
hum. humerus, *r.* radius, *u.* ulna, II and III, digits, IV metacarpus of fourth digit.

The *hind-limb* presents more variability in the degree of reduction (Fig. 3). The third digit may have two or three phalanges, while the second may have one or two; or, in the latter, they may be altogether wanting, and only a vestige of the metatarsus appear, as shown in Fig. 3D. The fourth digit is wholly wanting, as in the fore-limb, but may be represented by a vestigial metatarsus. In the tarsus a single proximal bone occurs, which probably represents the fused tibiale and fibulare, and in the distal row either one or two separate elements are present. Where two occur, as in Fig 3A, they are the tarsalia of the third and fourth digits, and where only one it may represent the fusion of these two, as in Fig. 3B, or it may be median and represent

the distal tarsal of the third digit, as in Figs. 3C and 3D. In Fig. 3D the elements, one on each side of the median single digit, are probably to be interpreted as the reduced metatarsals of the second and fourth digits, the corresponding distal tarsalia having disappeared, leaving only the one in connection with the axial digit.

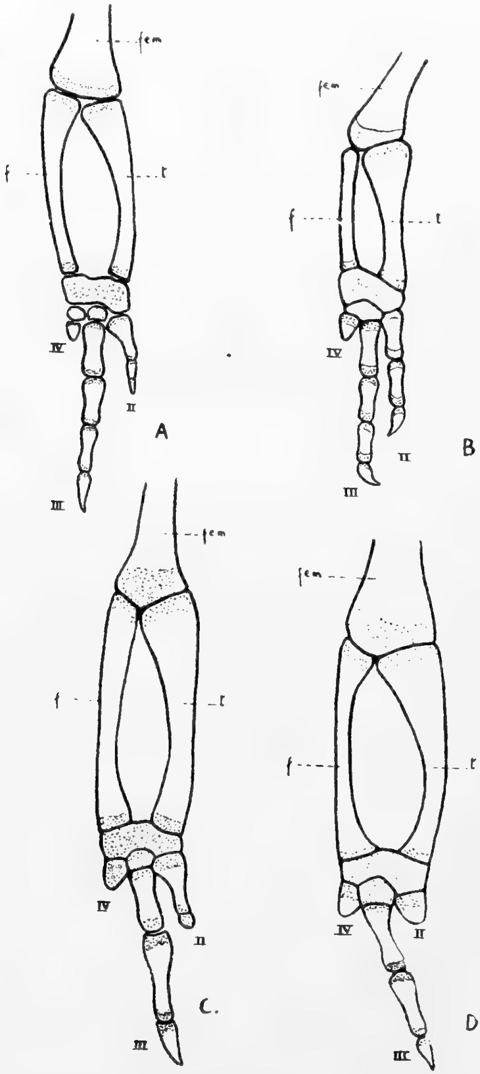

FIG. 3.—Various stages in reduction of hind-limbs of *Chamaesaura anguina*. *fem.* femur, *t.* tibia, *f.* fibula, II and III digits, IV metatarsus fourth digit.

CHAMAESAURA MACROLEPIS.

Reduction has proceeded further in this species than in the two preceding (Fig. 4). The fore-limbs have entirely disappeared, though the corresponding pectoral girdle has been found to be present in its entirety. Outwardly the hind-legs are styliform and measure only 6 or 7 mm., and are wholly undivided, terminating in an extremely minute claw. On dissection it is found that all the digits have disappeared except one. From its symmetrical position and from comparison with the stages in the previous species, this is regarded as the third or middle of the pentadactyl series. Only two phalanges, however, are present, the second being vestigial, and but a single metatarsus occurs. The tarsus is represented by a single undivided bone which, from comparison with the condition in the hind-limb of *C. anguina*, is probably to be regarded as the fused tibiale and fibulare, the distal tarsalia having wholly disappeared. The bone extends partly upwards on its post-axial side in order to reach the fibula, which is somewhat shorter than the tibia, as if it were already started on a course of degeneration.

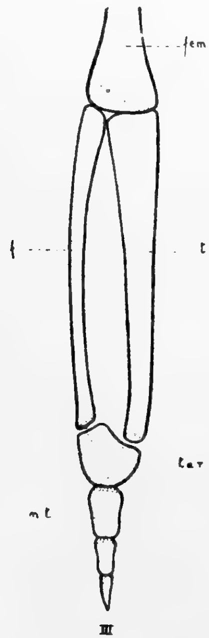

FIG. 4.—Hind-limb of *Chamaesaura macrolepis*.

fem. femur, *t.* tibia, *f.* fibula, *tar.* tarsus, *mt.* metatarsus, III digit.

Discussion.

There is no reason to question that the three species of *Chamaesaura*, or the originals of the stock from which they came, were at one time more conformable to the usual plan of structure of the Lacertilia, that is, were possessed of larger pentadactyl limbs and of a tail more nearly of the same length as the body. Further, it would be in harmony with the usually accepted interpretation of evolutionary zoology to regard the three species as representing a successional series in the process of limb degeneration: first, a general diminution in size without the loss of any of the parts; second, the orderly loss of the first and fifth digits and later of the fourth and second, followed by the corresponding metacarpals and metatarsals and elements of the carpus and tarsus; and, finally, the complete degeneration of the limb as a whole. All the available stages would be regarded as so many steps, one following upon another, in the gradual loss of the limbs. If a larger number of individuals were procurable a continuous series could in all probability be arranged, showing all the stages from the pentadactylous condition to the tridactylous, didactylous and monodactylous, to a condition of complete absence, thereby adding another to the many examples already elaborated and accepted as evidence of continuous or determinate variation.

Apart from the possible influence of selection, however, there appear to be no experimental observations which afford any support for such successional changes taking place in nature. Mutational changes, so far as we know them, are haphazard and disconnected, and probably never constitute a continuous series in any one direction. Hence there seems to be little or no experimental proof in support of continuous or determinate evolution, even though results in comparative anatomy and palaeontology call insistently for it.

How then are we to regard the facts as here presented? It is manifest that in the genus *Chamaesaura*, as in other well-known genera of the Lacertilia—*Anguis*, *Ophisaurus*, *Tetradactylus*—the germinal factors concerned with limb production are, or have been in the past, in a highly mutative state; and, as a result, we have the many departures from the normal limb condition characteristic of the lizards. It by no means follows, however, that the mutative changes of the limb factors would always be of the same degree, nor express themselves exactly in the same fashion; and this variability, combined with subsequent intermingling, may well have produced the many stages occurring within the various genera. Without calling for an orderly succession of germinal changes, we may conceive that in the case of *Chamaesaura* different and independent factorial changes, along with the later combinations resulting from inter-breeding, have given us the different stages in limb degeneration which we now possess. Reduction in size of limb, as we know it in *C. aenea*, may have occurred as a single mutation; the reduction in size and the varying losses of the digits may also have occurred in *C. anguina* as independent separate mutations, and apart from the

changes in its near ally. Similarly with the monodactylous condition of the hind-limb and the complete absence of the fore-limb exhibited by *C. macrolepis*. Slightly different mutative changes in the different individuals of the same species, along with later germinal intermingling within the species, may thus have produced all the variety we now find, a variety which almost suffices to give the appearance of a continuous series between the two extremes.

We have no evidence to show that the germinal changes which have already brought about limb degeneration in *Chamaesaura* will be continued, and that *C. aenea* will pass into the stage represented by *C. anguina*, and the latter into that of *C. macrolepis*, and that ultimately the limbs of all three species will disappear, as has already happened to the fore-limbs of the last-mentioned. There is much in favour of the belief that degenerative stages, as we know them, are permanent for the time being, and are not necessarily stages in the direction of still further losses. Thus, we have palaeontological evidence that the tarso-metatarsus of the ostrich, comprising the large middle metatarsus and the incomplete second and reduced fourth metatarsi, has undergone no further change since the Pliocene days of the Siwalik deposits, nor that the large third toe and the fourth small one have varied in their relative size during this long period. The vestiges of the hind-limbs and girdles in boas and pythons can, with no justification, be held to be still undergoing changes which will ultimately complete their degeneration; similarly with the relics of the hind-limbs or their girdles in Cetaceans and Sirenians. In the course of evolution factorial changes have brought the structures to the condition in which we now find them; but we have no reason to suppose that further changes will occur in the same direction, and thus complete the degeneration already initiated.

A CURIOUS CASE OF VETERINARY CLINIC PRACTICE.

BY

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AND

S. Pinto,

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Read July 11, 1922.

Abstract.

An account was given of a small dog which, when only six weeks old, showed marked physical discomfort, and was found to be infected with the tapeworm, *Dipylidium caninum*. Treatment by male fern and scammonia resulted in the expulsion per anum of more proglottides of the worm, but the scolex was not expelled. On the reappearance of symptoms, the treatment was repeated, with similar results. Two relapses occurred subsequently, and a fifth relapse was accompanied by other systemic disturbances, attributed to the worm infestation, but no worm proglottides were expelled after administration of the vermifuge. The dog's suffering increased, and a painful spot, changing in position, was localised by palpation, and a small, soft, painful tumour developed in the left flank. This was operated on, and a deep abscess reaching to the peritoneum, and with adhesions, was evacuated, irrigated with Dakin's solution, and dressed. When the dressing was removed, a metal wire was discovered, that proved on extraction to be a sewing needle with thread attached. Evidently it had been swallowed, and in its passage through the alimentary tract had caused localised pain, and in its passage across the abdominal viscera to the flank had carried bacteria from the intestine or had acted as an inoculating needle for the same. After discharge of pus had ceased, the surfaces of the wound were scraped and the edges stitched, rapid healing resulting. Complete recovery ensued, but the tapeworm, originally thought to be the primary cause of the trouble, has reappeared again.

As helminthiasis is usually associated with depraved appetite, the swallowing of the needle by the puppy is not surprising.

An interesting feature was that of the occurrence of *Dipylidium caninum*, 76 centimetres long, in a puppy only six weeks old, and the resistance of the Cestode to treatment.

SOME MOLLUSCAN INHABITANTS OF THE NATAL LAGOONS.

By

F. G. Cawston, M.D. Cantab.

Read July 11, 1922.

Visitors to the mouth of the Umgeni River and excursionists on the Durban Bay, or at Isipingo frequently remark on the large number of shells attached to the trunks of trees or lying free on the mud when the water has subsided.

Cerithidea decollata is a dark brown long spiral shell that clusters in great numbers on the mangroves in the estuarial swamps all along the Natal coast. Mature specimens are commonly an inch-and-a-quarter in length. At Isipingo I have found it associated with *Littorina scabra L*, and *Assemania bifasciata* Nevill. In the Durban Bay I have found it with *Littorina scabra*, *Alectrion kraussianus* Dunker, *Natica marochiensis* Gmelin, and *Volema paradisaica* Reeve. In the Illovo and Umgeni lagoons, I found it associated with *Theodoxus natalensis* Reeve.

No cercariæ could be detected in the rather brackish water in which these examples were found. I found a shell of the genus *Cerithidea* lying on the mud of the Karridene lagoon. It was not quite mature and only slightly decollated. Mr. Henry C. Burnup stated that the sculpture is very different from that of *C. decollata* and writes: "I am fully convinced it is the long lost *Cerithidea inæquisculpta* Kob. The spiral grooves are wider apart and tersect the transverse ribs in your shell, while in *decollata* they are finer, more numerous and are confined to the intercostal spaces. An occasional rib in your shell is much finer than its fellows. This feature might suggest the specific name, *inæquisculpta*. I believe it has never been collected except by the discoverer, Freytag, some time prior to 1893, the date of the publication of the description, and he only got one worn specimen at Durban. The locality has been doubted through the shell never again having been found."

Another common operculated shell from the Natal lagoons is *Theodoxus natalensis* Reeve, which I have found in large numbers in the Tongaat and Umkomaas lagoons. One example from Tongaat was not quite an inch high, one from Umkomaas $\frac{7}{8}$ in. I have collected examples from the Umbogintwini, Illovo and Umgeni lagoons. In regard to one I sent him from the last locality, Mr. Burnup says: "The *Theodoxus natalensis* is the largest I have, save one from Umkomaas. It is also the highest

in the spire that I have seen, has the spire less eroded than I have seen in any large specimen, has the plaits on the columella lip, or 'shelf,' better developed, and the gray colour is unusual."

From Tongaat and Umkomaas I have collected an almost black *Theodoxus* which is quite distinct from *natalensis*. Mr. Burnup says: "The coiling of the whorls is quite different. It is very like *T. gagates* Lam, from Mauritius, etc. (a species not hitherto recorded from South Africa), coiled in the same way and with the red stain on the parietal callus; the opercula, too, seem to correspond exactly, but I have no specimen of *gigates* so finely marked with zig-zag yellow lines."

In October, 1920, I collected specimens of *Septaria*, a genus new to the South African list, from the Umbogintwini lagoon. This operculated shell of brackish water belongs to the family Neritidæ. I have now found numerous examples in the Umkomaas lagoon and others at Karridene, Illovo and Amanzimtoti. Those from the Umkomaas lagoon appear to include two distinct forms, one broad with very short septum; the other narrow, with longer septum. A difference in colour markings seems to coincide with the difference in shape. The larger shells were proportionally narrower than the younger shells.

At Umbogintwini I found *Oxystele tabularis* Krauss, which would also appear to be an occasional inhabitant of brackish water in lagoons.

Inhabitants of Fresh Water in Lagoons.

In an overflow pool which drains into the Umgeni lagoon and contains quite fresh water, I have found numerous examples of *Tiara tuberculata* and *Modiola capensis*. Three of the Modiolæ were finer than those in the Burnup collection, but a little short of Krauss's type, which is almost 22 mm. long. My longest was 19 mm. Some of these Modiolæ were infested with cercariæ whose tails were divided for the complete length. The Tiaræ were heavily infested with cercariæ, resembling *C. cawstoni*. This cercaria is closely allied to that responsible for Lung Fluke disease in the Far East, which is contracted through eating the crabs in which the cercariæ have encysted; so that the presence of numerous small crabs in the pools at the Umgeni mouth where *Tiara tuberculata* exists in great numbers may be of some importance.

High up the Illovo lagoon, in an overflow pool, I found several examples of *Sphærium*. Mr. Burnup reports: "I think it must be *Sphærium ferrugineum* Krs, which does not seem to have been collected in South Africa since the types were taken in 1846. Connolly collected it at Victoria Falls." On the same water-weeds I found some land shells, *Succinea*, probably *patentissima*—a rare form which Mr. Burnup has once found at the edge of the Umgeni lagoon.

I am told that when the river subsides numerous bivalves, about half-an-inch in length, are to be found on the rocks at the mouth of the Umbogintwini.

Inhabitants of Rivers Found in Natal Lagoons.

After the rains I have found numerous inhabitants of semi-stagnant pools washed downstream, attached to floating vegetation or lying on the sand-bank at the mouth of the rivers. Many others can be found breeding on the water-lily leaves or rushes at the edge of the lagoon where the water is not too salt.

On the sand-bank at the mouth of the Amanzimtoti River I found *Physopsis africana* and *Limnæa natalensis*, which had been washed downstream. The latter was found breeding all the way up the river and, in places, was associated with *Ancylus* (two varieties), *Isidora forskali* and small *Planorbis*.

At the mouth of the Umbogintwini river I found numerous *Limnæa natalensis* crawling about on the sand at the water's edge and, at the stagnant part of the lagoon, I found *Planorbis pfeifferi* breeding on water-lily leaves.

From an overflow pool close to the Illovo lagoon I have collected *Planorbis pfeifferi*, *Segmentina planodiscus*, *Isidora* (probably *tropica*) and *Ancylus*.

On the Tongaat beach I have found numerous Ancyli attached to the rocks over which a small rivulet was breaking into the sea.

Some fresh-water inhabitants from a stream along the course of the river at Karridene—*Physopsis*, *Planorbis pfeifferi*, and *Limnæa natalensis*—were rapidly killed when placed in a bottle containing lagoon water and brackish water inhabitants.

Physopsis africana is the common intermediary host of *Schistosomum hæmatobium*, *S. mansoni* and *S. bovis* in Natal. *Limnæa natalensis* is sometimes heavily infested with *Cercaria pigmentosa*, the larval stage of *Fasciola gigantica*, and Porter has found it infested with *Fasciola hepatica* at times. *Isidora tropica* and *Isidora forskali* are sometimes infested with Amphistomes, whilst *Planorbis pfeifferi* is commonly infested with cystophorous and other cercariæ. All these common inhabitants of Natal rivers are occasionally infested with Schistosomes. It is interesting to note that neither the cercariæ themselves nor their intermediary hosts can survive for any length of time in the brackish water that is generally present in the lagoons of Natal.

These investigations have been carried out under the auspices of the Streatfield Research Fund of the Royal Colleges of Physicians and Surgeons.

VARIATION IN THE TENTH RIB OF THE PENGUIN.

BY

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Professor of Zoology, Rhodes University College,

AND

VIVIAN FITZSIMONS, B.Sc.

With Plates VI—VIII.

Read July 13, 1922.

Before the Mendelian conception of the discreteness of characters obtained recognition, it was generally held that variations appearing in Nature would tend to be "swamped," so long as inter-breeding was possible; a measure of isolation, geographical or physiological, was demanded for the persistence and spread of a new variation. It is manifest that on the supposition that characters would blend, it was to be expected that the intermingling of forms differing but slightly would tend to produce an approximate uniformity in development of any one of the characters. Now that attention is concentrated upon the actual behaviour of characters in breeding, practically all the results are seen to be a contradiction of the notion of blending or swamping. Results procured from a study of variation in the highly gregarious penguin, *Spheniscus dermersus*, Linn., seem deserving of record as illustrating the persistence of variations among individuals of the same species, living and breeding in the closest association with one another.

A collection of fifteen young penguins, some just hatched and others about to hatch, was obtained from Bird Island,* and an examination of the skeletal and other characters for evidences of variation revealed certain marked differences in connection with the last pair of ribs. In Vol. VII of the "Challenger Reports," Dr. Morrison Watson contributes a full account of the skeleton of the Spheniscidae, but records very few variations among the ribs. Ten vertebral ribs are stated to occur throughout the family. Where, as in *Eudyptes chrysocome*, only nine are given by some writers, it is held that as the tenth is always very slender

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* Bird Island is one of the many islands, rocks and reefs, comprised in the large group of the Government Guano Islands, situated off the western and southern coasts of South Africa, lying between latitudes 24° 30′ and 35° South; and longitude 14° 20′ and 26° 30′ East. We are under obligations to the Superintendent of the Islands, Mr. H. Jackson, for permission to obtain specimens.

and not connected with the vertebral column, it has been lost or overlooked. The sternal ribs are eight in number, completing the vertebral ribs from the third to the tenth. The eighth sternal rib, attached to the tenth vertebral segment, does not reach the sternum, but is connected with the seventh sternal rib and, according to Watson, is also easily overlooked on account of its vestigial nature.

The specimens were all dissected so as to display the sternum and the ribs on each side throughout their extent. In most of them the proximal portion of the vertebral segments was ossified, but the distal portion and sternal segments were in the cartilaginous condition. The series represented by Plates VI—VIII, Figs. 1 to 9, indicate the chief variations met with. In each specimen the eighth and ninth ribs are fully developed, and reveal no important variations; hence by representing the tenth in its natural relationship with them, the degree of variation is accurately displayed.

In the specimen from which Fig. 1 is drawn no trace whatever of a tenth rib, vertebral or sternal, occurs. The ninth is slightly more slender than usual, and its sternal portion is closely united to that of the eighth for practically the whole of its length. In Fig. 2 a narrow strip of cartilage, measuring about 5 mm., lies against the sternal portion of the ninth rib, and the conditions represented in other specimens indicate that this is to be regarded as a vestige of the tenth rib. Fig. 3 shows a longer strip of cartilage in the same position, and in Fig. 4 it becomes still longer, while in Fig. 5 it extends the full length of the sternal segment, closely united with it all the way. In the specimen from which Fig. 5 was drawn a small isolated strip of cartilage was found embedded in the muscles posterior to the ribs. Fig. 6 reveals the tenth sternal rib in its complete length, with a vestige of the vertebral rib attached to it, but clearly separated by an articulation. In Figs. 7 and 8 the sternal rib of the tenth is also seen to be fully developed, but is very slender and for the most part attached to the ninth, while the vertebral moiety is much longer. Fig. 9 represents the furthest stage reached in any of the specimens examined. On the right side the vertebral rib is incomplete, while on the left the rib is fully complete in both its sternal and vertebral portions, the latter connected with the vertebral column by a tubercular and a capitular process. Extending from the sternal segment is a process, slightly longer on the left side than on the right, which is manifestly a vestige of the sternal part of an eleventh rib, though no line of separation from the tenth can be made out.

Though the results have been arranged in this orderly sequence, so as to show an almost continuous series between the one extreme and the other, that is, between the entire absence of the tenth rib on the one hand and its complete development on the other, it is by no means intended to imply that this is the manner in which the variations have actually been produced in Nature. It has often been pointed out that sequences of this

kind, built up from individuals whose genetical relationships are unknown, are unreliable as indicating evolutionary stages. It is, however, manifest that, compared with the rest of the ribs, the tenth pair is in a high state of hereditary variability within the species. One is probably justified in assuming that the variability is associated with the process of degeneration of the particular pair; but whether the process is actually in progress at the present time can be determined only by taking the mean of a sufficiently large number of measurements, and then comparing it with a similar mean after an interval of time.

That the variability is hereditary or germinal, in contrast to fluctuating, may be inferred from the fact that the other ribs show no individual variation of any significance. The first and second vertebral ribs are incomplete with no sternal portions, and the first is only about one-third the size of the second. Yet in all the specimens examined they show no departures from these conditions. One would expect that ancestrally these two ribs were complete, and that their present reduced size is a result of retrogressive evolution. Manifestly the process of reduction has now ceased, and with regard to them there is germinal uniformity throughout the species. The tenth pair alone has a varied germinal representation, and the somatic variability in the different individuals is evidence of this.

Discussion.

Similar series of variations have been obtained in studying certain characters of the ostrich, which may also with good reason be assumed to be in a degenerative phase.* The feathers of the wing, the second phalanx of the third finger, the claw on the small outer fourth toe, and the scutellation of the big toe all show different hereditary stages in retrogressive evolution, when numbers of individuals are available for comparison. As in the case of the tenth rib of the penguin, they are held to represent different genetic stages in evolutionary degeneration reached by the structures in question; but whether the losses are still in progress at the present time is not determinable, and is immaterial to the purpose of this paper. It is desired to emphasise that where a structure is in a degenerative phase the individuals making up the species are not necessarily at the same stage; some have retrogressed further than others; also, that though interbreeding may be carried on, these stages do not lose their identity by blending, nor result in a uniformity of the character in question.

Stages such as those presented by the penguin and ostrich are the anatomical evidence of the way in which degenerative evolution proceeds, and have to be accounted for in any complete theory of evolution, a desideratum yet far from realisation. For

* "Methods of Degeneration in the Ostrich." *Journal of Genetics*, Vol. IX, Jan., 1920.

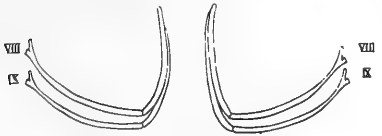

Fig 1

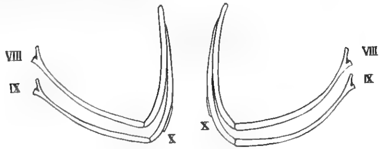

Fig 2

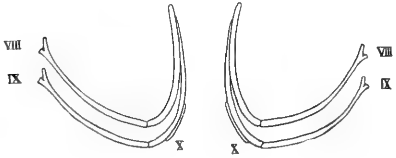

Fig 3

VARIATION IN RIBS OF PENGUIN.

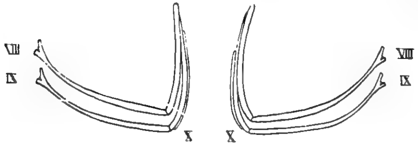

Fig 4

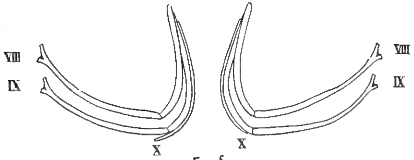

Fig 5

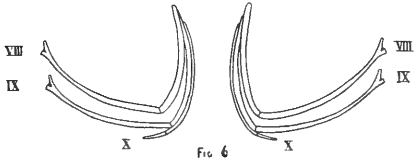

Fig 6

VARIATION IN RIBS OF PENGUIN.

Fig 7.

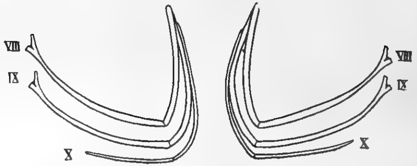

Fig 8.

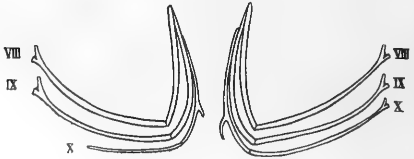

Fig 9.

VARIATION IN RIBS OF PENGUIN.

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the most part, the anatomical and palaeontological evidences of evolution seem to call for successive series of germinal changes in the same direction, but it may well be doubted whether this is their real interpretation. Apart from the influence of selection, no experimental evidence is forthcoming in favour of germinal changes taking place in any successional order. Mutations, as we know them, are haphazard and independent of one another, following in no definite order; each appears to be discrete and apart from the others. Often, however, the germ factors controlling certain characters seem to be in a more mutative state than others, and the germinal changes and resulting mutations are not necessarily the same or of the same degree in different individuals. Thus, we may assume that the germinal factors controlling the tenth rib of the penguin are, or have been, in a more changeable state than those controlling the remainder of the ribs, and this, along with the interbreeding of the different individuals, has given us the great variation now encountered. The variation is of such a character that it suffices where a sufficient number of individuals are available to produce a continuous series extending from one extreme to the other. As a result of interbreeding, these variations do not now necessarily represent the original germinal changes; they are intermixtures of the different factorial states; much less do they indicate that the changes were in an ordinal sequence, leading to the loss of the rib in a continuous fashion.

It is manifest that the last pair of ribs coming, as it were, at the boundary between the thoracic and abdominal regions of the body may be subject to different stimuli from the other members of the costal series, and would respond more to any changed habits of the bird. And if we could follow Mr. J. T. Cunningham,* and hold that these stimuli produce hormonic secretions capable of influencing the germ plasm, then we have a means by which the variations may have been induced and limited to the structure in question.

If no selection of any kind is introduced, and no further mutations occur, penguins will presumably continue to give all the variations in the tenth rib here described, without the latter ever being suppressed. If selective breeding could, however, be instituted it would be possible on the one hand to produce a race in which the tenth rib would be altogether suppressed, and, on the other, a race in which it would be completely developed along with a portion of the eleventh. These would be races in which germinal purity had been attained by the elimination of other divergent factors, a condition very different from that of the penguin at the present time.

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* "Hormones and Heredity," London, 1921.

METALLIC SUTURE OF BONES IN THE CASE OF FRACTURES.

BY

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Read July 13, 1922.

SUMMARY.

For several reasons it is advisable and sometimes necessary to operate on clean and uninfected fractures, and make a suture of the bones so as to be able to have them in a good position and obtain a good union of the two extremities of the bones.

As regards the metallic instruments with which this union may be made, we may employ various kinds of plates and pins. The most commonly used are Lane's plates fixed by screws.

To-day we are employing also a sort of pin, the Dujarier's agrafes, which are fixed on the bones after making two small holes to hold the extremities of the agrafe.

There are some difficulties and dangers in the operation on the bones from infection that may sometimes develop, and for this reason it is necessary to operate with the best antiseptic precautions and without touching the bones with the fingers, even if gloved.

With the Lane's plates, experience shows that infection occurs sometimes, and the plating is much more difficult without touching the plates and the screws. We have been using recently the agrafes and we have found that the operation can be done in an easier way, and that there is less likelihood of infection. The fixation of the bone is made absolutely good and steady by putting two agrafes in a square position.

ECONOMIC ENTOMOLOGY IN MOÇAMBIQUE, AND ITS PROBLEMS.

BY

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Read July 13, 1922.

Visitors to and travellers through this country (Moçambique) cannot help being impressed by its great agricultural possibilities. There is no doubt that in our soil and climate we have resources which should make this Province one of the richest in South Africa. A fertile, deep soil, a congenial climate, and a harbour for export—second to none in the whole continent—certainly are three assets of which we may well be proud, and which will put this Province in the foremost rank of agricultural producers and make it one of the most prosperous and highly prized of the possessions of the Mother Country.

At present we are only at the beginning of our agricultural development. Whilst a very good start has been made, there are still tremendously vast areas which are practically untouched or even unexplored. But gradually we see large tracts being developed with a view towards export of agricultural produce in its widest sense.

The Government, being fully aware of the potential wealth which this country possesses in its agricultural development, has for a long time maintained a Department of Agriculture, the duty of which is to advise agriculturists on all matters pertaining to their vocation. Mistakes are costly in all lines of business, especially so in agriculture on a large scale, where a mistake may mean the loss of an entire year's profit, or where it may endanger even the whole future of an enterprise.

It is, therefore, evident that in a country like this a well-equipped, well-staffed Agricultural Department, with fully qualified experts at the head of the various divisions, is a most valuable institution; in fact, it may well be called the backbone of the country's future prosperity.

Now, agriculture comprises so many subjects that it is impossible for one person to acquire expert knowledge of all its branches, and the department is, therefore, divided into several sections, each confining itself to one particular branch of the science. One of these sections is that of entomology.

Importance of Entomology.

Very few people realise the all-important *rôle* which insects play and the influence they exert upon the development of agriculture, besides their effect upon practically all lines of human endeavour. The amount of injury caused by insects, and the financial losses sustained yearly through their depredations, is truly enormous and beyond calculation. In all its stages a crop is subject to the attacks of insects—from the sowing of the seed, throughout the growing period, during harvesting, storing and shipping the insects exact a heavy toll, often ruining the crop entirely or reducing the profit to a minimum. Other insects, again, inhabit the dwellings of man, destroying his food or belongings, or sucking his blood and annoying him in various ways, or by carrying disease and transmitting disease germs, endangering his life. Others, again, attack the food stored in warehouses, or ruin a great many valuable substances, or undermine the buildings themselves. Orchards and timber plantations often suffer very serious damage through insect depredations, and on all sides man finds himself beset by these implacable enemies, small, but powerful through their enormous numbers, disputing with him his title of monarch of the world.

Now, the ultimate aim of the economic entomologist is to give advice as to the best methods either to prevent these insects from becoming a menace to man, or, if they are once established, to check their increase and put a stop to the damage which is being inflicted. To be able to give such advice calls for not only a thorough knowledge of insect life in general, but special training in the practical application of the science and considerable experience of local conditions and their influence upon the habits and propagation of the insect under consideration. Insect life and development are greatly dependent upon climatic conditions and local vegetation, and until we know these we cannot successfully undertake the control of the injurious species.

It is my intention to summarise very briefly what has been done in the way of economic entomology in this Province, the problems to be faced, and some suggestions as to the methods to be pursued in solving these.

Earliest Workers in Entomology of this Province.

For our earliest information on the insects of this country we are indebted to missionaries and travellers who collected the most striking forms and made some desultory observations on their transformations, food plants and habits. Amongst these we find the name of Monteiro and Junod as the outstanding figures. Thanks to their efforts we were supplied with data on the occurrence and, to some extent, the distribution of the more common species. But these captures and observations were made practically from the collector's viewpoint, and the economic aspect was entirely lacking. With the appointment of Howard as Entomologist to the Department of Agriculture conditions changed,

and now we find the economic value of entomological studies emphasised. The principal insects injurious to crops were studied, and remedies, based on the previous experience gained in the Union, were advised in order to assist those engaged in agriculture. A determined effort was also made to establish an information service on the movements of the migratory locusts in co-operation with the South African Locust Bureau. Howard being especially interested in insects which transmit diseases to man or animals, more detailed studies were made on ticks and the distribution of the various tsetse flies, and maps were prepared and published giving the localities of the occurrence of the different species of Glossina in this Province. Before he left he was engaged in a study of the fleas infesting the various wild and domesticated animals here, but the results of these investigations I have not seen published.

Stimulated by his example probably, another investigation was undertaken of the occurrence of tsetse fly belts in the Quelimane district, and a more detailed map prepared showing their distribution. I have been able, on a recent trip through that district, to verify the general correctness of the data there given. Lastly, a trip made by Barrett in 1910 along the Rovuma River, the most northern boundary of this territory, still further increased our knowledge on this subject.

After the departure of Howard in 1912 economic entomology here came practically to a standstill. Due to the War and its aftermath, there was a period of over eight years before an entomologist was appointed, when the writer was invited to take up these duties.

It was soon found that the difficulties confronting the economic entomologist in this country are very great indeed. Apart from the financial stringency, a condition which is found in practically all countries at the present time, and which prevents the Division being supported as much as is desirable or even necessary for effective work, there are conditions here which are totally different from anywhere in South Africa. Data on tropical crops are entirely lacking, while those on the insects of sub-tropical and other crops are for the most part not applicable here. Besides, the same crop here is often attacked by entirely different insects from those which endanger the success of its cultivation in the Union. It meant, therefore, starting *de novo* to try and work out our own salvation.

Before starting the study of the insects and their control in the Province it was, of course, desirable to prevent the introduction of new ones. Our first work, therefore, was to establish an efficient inspection service of all plants which were being imported. The value of this inspection may be judged from the fact that twice we have intercepted the dreaded pink boll worm (*Pectinophora gossypiella*, Saunders), the most serious pest of the cotton plantations, whose introduction would have seriously handicapped the cotton industry from the start and have cost

the State tens of thousands of pounds to control, besides endangering the cotton industry of the whole of South Africa. Its interception was the more fortunate because, in a recent trip through the cotton fields of the northern districts, no indications were found of the presence of the pink boll worm, so that there is a great probability that this Province, besides the Union of South Africa, is one of the few countries in which this scourge has not yet become established.

Entomological Problems of this Province.

Having thus secured ourselves against introduction of agricultural pests from outside, a start can be made with the study of the insects, injurious and beneficial, of this country. We find that, entomologically, this Province is practically *terra incognita.* I do not mean only from a collector's point of view, in regard to which this would be an extremely interesting field, but also from the point of the economic entomologist, the insects either actually injurious or potentially so are very varied and different from those met with in other parts of South Africa. As an illustration I may mention that, while in the cotton fields of the Union the greatest enemies of the cotton plant appear to be various leaf-eating larvae of Noctuidae, we find here in our northern Provinces, although these just-mentioned pests are present in considerable numbers, the greatest amount of damage is inflicted by three small stem-boring beetles of the family Curculionidae, namely, *Apion constrictum* (Hartmann), *Apion consimile* (Wagner), and *Apion considerandum* (Fhs). Similar species have been reported from Tanganyika territory, but, from the accounts given, were not sufficiently numerous to cause apprehension. In our northern districts, however, we have seen stretches of a hundred hectares and more totally ruined by these insects. Again, while the cotton stainers of the genus Dysdercus are present, as elsewhere, we found that in some localities their place was taken by an entirely different species, *Callidea dregei*, and in those places the Dysdercus were conspicuously absent.

In the sugar plantations we have found the adults of a certain root-feeding Scarabaeid, as yet undetermined, present in enormous numbers. Although we have not yet had time or opportunity to make a study of this insect, the experience in other sugar-growing countries with insects of the same group—I only need refer to the fight against *Phytalus smithi* in Mauritius and the efforts made in the West Indies to control the various species of " hard backs "—is sufficient to cause us great apprehension in regard to the injury which may be caused by this species here. Again, the presence of enormous numbers of various species of Bostrychidae, for the greater part not previously reported from this locality, and of Platypodidae, which were nearly all new to science, was an unwelcome sign of potential future injury. Considering that these small species are all wood borers, and that some have been known to attack standing cane, it is evident that this matter calls for thorough investigation at the earliest possible date.

Examples like this could be multiplied indefinitely as applying to nearly every one of the main crops.

Another great group of important insects which has not been studied to any extent anywhere in South Africa is the forest insects. This Province can boast of the possession of magnificent forests containing very valuable species of timber—a source of wealth which is, as yet, only very superficially explored. The conservation of these forests and their scientific and economic exploitation certainly deserve to be made a matter of prime consideration by the Government, and the control of insects will play an important part in the ultimate value of these resources of the country. Already complaints have reached us from the few places where timber is being cut and utilised of the damage done by insects to the standing or recently-felled trees. Furniture made of native wood is in danger of obtaining an unenviable reputation for its being prone to insect attack. These forest insects are for the greater part as yet unknown to us, while the *rôle* played by the seed-eating insects, in affecting the health of the native forests or their increase, or in preventing the natural re-afforestation, is an interesting and all-important one. The experience of other countries has taught us that the investigations on these matters have, as a rule, come a few generations too late: let us not make the same mistake.

I have not touched on the subjects of sanitary, medical or veterinary entomology, but enough has been suggested to show that the task of the economic entomologist in this Province is a formidable one, calling for the services of not one, but several, trained observers and investigators, if we wish to be in time to prevent incalculable damage and to assure the agriculture of this Province that degree of prosperity to which its conditions of climate and soil entitle it.

The Methods to be Employed.

What methods shall we employ to deal most effectively with these various problems? First of all, it behoves us to take stock of the enemies arrayed against us, and of the auxiliaries which Nature has already put at our disposal in the way of parasites and predaceous enemies of these. *This means a thorough entomological survey of our territories*, to be undertaken conjointly with a *botanical survey*. By knowing the insects at present affecting native vegetation and their food-plants we can more or less predict which insects will be troublesome when these native food-plants are being destroyed to make room for crops consisting of plants belonging to the same or nearly allied families. Such a survey will be not merely of a scientific interest, but of the greatest practical value, for we may thus be able to prevent damage instead of being called upon to give remedies for its control after a great deal of injury has been done.

Our next step is the investigation of the life-history of these insects. Professor Osborne, one of our foremost American ento-

mologists, has rightly maintained that "life history work is the basis of all economic entomology." While this statement has never been challenged, the interpretation of the expression "life history" has often been very varied. What I mean is that, in many instances, "life cycle" has been considered synonymous with "life history."

In order successfully to combat an injurious insect it is, of course, essential that we should know what are the different stages it passes through in its development, and at what time during the season these stages occur, so as to find out its weakest stage, when it will be most successfully destroyed by the application of insecticides or other methods of control. Valuable as are the data gained by such an investigation, they are not sufficient to allow us to control the insect in the most effective and most economical manner, and I take this opportunity to make a plea for breaking away from the old time-honoured methods of insect control and seeking for new ones. The methods thus far employed, and first introduced and worked out in detail by the pioneers in economic entomology of the United States Department of Agriculture, have undoubtedly saved millions of pounds' worth of crops, and agriculture owes them a debt which it can never repay. Nevertheless, our present methods are artificial, expensive and cumbersome. In Nature we find that it is only under very exceptional conditions that the wild vegetation is destroyed to such an enormous extent as we find taking place year after year with our cultivated crops, and, even if this happens during one season, the balance is quickly restored. The reason is not far to seek. Nature has provided an extremely complex system of balancing factors, influencing the abundance of the various species of plants and animals. There are climatic conditions, such as alternate heat and cold, abundance, intensity, periodicity of rainfall, even in the case of some insects, the presence or absence of sunshine, humidity and texture of soil, atmospheric movements, all of which may have an influence at times on the development of certain insects. Besides, there is another complex of parasites, primary, secondary, tertiary, even quarternary, predaceous enemies, each and every one of them forming, as it were, a cog in the complicated machinery. As an example, I may mention the sugar cane leaf hopper (*Perkinsiella saccharina*), in Hawaii, where the parasite complex comprises some forty species of insects alone, not mentioning insect-eating birds and destructive fungus diseases. Interference with the normal development of any one of these forty will, in its turn, affect the abundance of the thirty-nine others, and thus ultimately that of the host. Now, each of our insects, injurious or otherwise, is the centre of a similar complex—in most cases as yet unknown to us—and it should be possible by interfering intelligently with one or more members of this complex so to influence the original host as to reduce its injuriousness considerably, thus counterbalancing the factor of abnormally abundant food supply introduced by the agriculturist. In our ignorance we have concen-

trated our efforts on the direct destruction of the host, thereby also interfering with the parasite complex and making Nature's task more difficult to cope with this same host insect the next season, and involving great expense of funds and energy. Now let us begin from the other end, and assist Nature in doing the work of re-establishing the balance.

There are encouraging signs that this viewpoint is gaining ground. The introduction of parasites into a country where the host has been introduced previously was a step in the right direction, and we all know the striking success achieved in some instances. While not going so far as the late Mr. Craw, of California, in considering the introduction of parasites as a panacea for all our insect troubles, the underlying idea is sound, and I think that a thorough study of the interactions between the various insects will enable us in time to make better use of the native enemies of our host insect in its control. The work of Mally—the well-known entomologist of the Cape Province—in his endeavours to breed parasites with a greater number of generations per season than normal, thus increasing their effectiveness in the control of the host—may be considered one of the many steps to be taken in this direction towards assisting Nature.

These matters call for an enormous amount of preliminary investigation, and probably a generation of entomological workers will pass before any really outstanding progress has been made. In the meantime we must continue to employ the old methods, and improve them, never losing sight of the ultimate goal, to let Nature repair where man has put her delicate balance out of joint. No doubt many mistakes will be made, and many efforts will be exerted in vain. However, the only way to achieve success is through a series of failures, and future generations will probably wonder as much at our present complicated system of machinery and chemicals for insect control as they will wonder why we considered it necessary to string miles upon miles of copper wire on poles in order to convey electricity.

ESTUDOS SOBRE AS BEBIDAS ALCOOLICAS CAFREAES FABRICADAS PELOS INDIGENAS DA PROVINCIA DE MOÇAMBIQUE.

POR

LUIZ SOROMENHO, M.D.,

Director do Laboratorio Quimico de Lourenço Marques.

Lido em 13 de Julho, 1922.

Por indicação do Chefe dos Serviços de Saude desta Provincia procedeu-se no Laboratorio Quimico do Hospital Miguel Bombarda ao estudo de varias bebidas alcoolicas fabricadas pelos indigenas de varios pontos da Provincia de Moçambique.

A relação destas bebidas é sem duvida incompleta visto que houve circunscrições que não enviaram áquele Laboratorio bebidas algumas e outras circunscrições só mandaram parte das bebidas que o indigena fabrica. Comtudo parece-nos que conseguimos obter amostras de todas, ou quasi todas, as bebidas que o indigena consome em mais larga escala.

Do Norte ao Sul da Provincia pode dizer-se que as bebidas fabricadas são identicas para todos os distritos com predominancia nalguns dumas ou doutras conforme a abundancia da planta original. Se no Norte se consome mais sura e mais vinho de mandioca do que no Sul, por serem as plantas produtoras dessas bebidas ahi mais abundantes, no Sul da Provincia tambem o indigena fabrica essas bebidas embora empregue mais o cajú e o milho.

Fabrica o indigena para o seu consumo duas especies de bebidas alcoolicas: as bebidas produzidas por fermentação e aquelas que depois de fermentadas são submetidas á distilação.

Á primeiras poderemos dar o nome de *vinhos*, ás segundas o nome de *aguardentes*.

O emprego da fermentacão parece ser muito antigo entre os indigenas. As bebidas fermentadas são fabricadas ou com frutos ou com farinhas. Conforme é uma ou outra a materia prima assim varia o processo de fabrico. Quando se empregam frutos são estes cortados em pequenos bocados, esmagados e esprimidos de modo a extrair o suco que, adicionado ou não de agua, é depois guardado por 24 ou 48 horas e findo este tempo está o liquido pronto a ser ingerido.

Quando se empregam farinhas é necessario formar primeiramente o *fermento* que se obtem pondo a germinar, durante 2 ou

3 dias, grãos de um cereal, geralmente mapira, e que depois de germinados e secos se reduzem a uma massa que se guarda. Obtido o fermento faz-se uma mistura da farinha em agua, mistura que se leva ao lume até á fervura, e á qual depois de fria se adiciona um pouco de fermento. O liquido é então deixado em repouso num sitio fresco: ao fim de dois ou tres dias está pronto a ser ingerido.

A *distilação* parece ser processo de acquisição recente empregado pelos indigenas sómente de ha perto de um seculo a esta parte. Foi certamente com os europeus que eles aprenderam a distilação para a qual empregam os alambiques mais rudimentares. Geralmente uma panela grande serve para conter o liquiso fermentado e que vai ser submetido á distilação, uma outra mais pequena, e colocada sobre aquela, forma o capitel do alambique. A união entre as duas é tapada com barro. A panela que serve de capitel ligam um cano de espingarda ou uma vara de bambú que fazem passar atravez de qualquer vazilha (geralmente a casca dum tronco de árvore) contendo agua fria para produzir a condensação do liquido que sae gota a gota pela outra extremidade do tubo.

São geralmente as mulheres que são encarregadas da preparação das bebidas. Diz-se que entre os ba-chopi a distilação faz parte da enducação da mulher e na época do cajú as raparigas adolescentes apresentam uma cicatriz de queimadura feita num dos ombros e que constitue o diploma da distilação.

Estas varias bebidas são ingeridas pelos indigenas sem distinção de sexos nem de idades. É de practica corrente forçarem as creanças de dois a tres anos a ingeri-las na suposição de que as tornam mais fortes.

A quantidade de bebida necessaria para produzir a embriaguez varia com a sua natureza e a sua graduação alcoolica. Essa quantidade, relativamente grande, 4 a 6 litros, para as bebidas fermentadas, é bastante mais pequena para as bebidas distiladas: meio a um litro.

Os sintomas da embriaguez são os vulgares da intoxicação alcoolica. A embriaguez é geralmente acompanhada de danças e cantos que só terminam pela queda do indigena provocada pelo cançasso e pela acção do alcool

No estudo das varias bebidas alcoolicas dos indigenas desta Provincia podemos fazer o seguinte quadro de classificação:—

(*a*) Vinhos (Bebidas obtidas por fermentação):

de frutos: Cajú.
Bimbe.
Ananaz.
Ocanhe.
Outros frutos.

de farinhas: Uputo (milho, mandioca, mapira, etc.).
Oteca ,, ,, ,, ,,
Pombe ,, ,, ,, ,,

de sucos de plantas: Sura.
Xichemelane, Chuaia Huai ou Sópe.

(*b*) Aguardentes (obtidas por distilação dos vinhos anteriores):

As principais são: Ag. de Cajú.
Ag. de Ananaz.
Ag. de Mandioca.

É por esta ordem que iremos estudar as diferentes bebidas alcoolicas.

Vinhos.

Cajú.—Bebida fabricada do fruto do Cajueiro, *Anacardium occidentale*, Lin., " ma-cajú " entre os indigenas. É do pedunculo carnudo do fruto que os indigenas extraem um sumo adocidado que submetem á fermentação para obterem o vinho. A frutificação do cajueiro e a preparação desta bebida faz-se durante a época chuvosa de Dezembro a Janeiro. O cajueiro é muito abundante em toda a provincia e por isso o fabrico das bebidas de cajú é geral de Norte a Sul. O consumo desta bebida só é limitado pelo tempo de fructificação da planta. Nessa época o indigena deixa todos os trabalhos para se entregar exclusivamente ao vicio da embriaguez.

A analise revelou-nos uma graduação alcoolica fraca 4°, 3 (amostra n° 23) e 5° (amostra n° 30), conjuntamente com uma pequena quantidade de aldehydos, de ethers e de alcooes superiores e ausencia de furfurol.

Uhimbe ou Bimbe.—É uma bebida fermentada feita com o fruto do " Bimbe," *Garcinia Livingstonei*, T. And., fruto que tem o tamanho e o aspecto de uma nespera e que amadurece nos mezes de Novembro e Dezembro.

É o seguinte o processo de preparação da bebida: os frutos são lançados num pilão e esmagados de modo a extrair o sumo. A este sumo junta-se-lhe agua e o liquido obtido é deixado em repouso durante dois dias findos os quaes está pronto para ser consumido. A analise mostrou que se trata de uma bebida fermentada de pequeno grau alcoolico: 4°, 8 (amostra n° 10), 4°, 3 (n° 14), 10°, 6 (n° 22).

No que respeita aos productos de distilação, vestigios ou ausencia de furfurol e de aldehydos, mas ethers e alcooes superiores em certa quantidade.

Ananaz.—É empregado pelos indigenas o fruto desta planta, *Ananas sativa*, Shultes, " si-nanze " dos indigenas, para preparar uma bebida fermentada e uma aguardente por distilação.

Os frutos amadurecem de Janeiro a Março e é nessa ocasião que o indigena prepara com eles as bebides alcoolicas. No Norte da Provincia é o ananaz bastante abundante de modo que este fruto é, depois do cajú, o mais empregado pelos indigenas do Norte para prepararem as bebidas alcoolicas.

O processo de preparação é identico ao usado para os outros frutos: a polpa do fruto é esmagada e o suco obtido é misturado com uma certa porção de agua e posto a fermentar durante uns dois dias, findos os quais está pronto a ser consumido.

O indigena póde consumir este producto da fermentação mas geralmente emprega-o para a preparação de aguardente. Não tivemos ocasião de analisar nenhuma amostra de vinho de ananaz.

Ocanhe.—Bebida preparada com o fruto da "Ocanha," *Sclerocarya caffra*, Sond.

O fruto é cortado, de modo a separar o caroço e a polpa, posto em vasilhas com agua, bem mechido e deixado a fermentar por dois ou tres dias ao fim dos quaes está pronto a ser ingerido. É bebida que se consome na época da maturação dos frutos de Janeiro a Março. Parece ser menos alcoolica que o uhimbe. Não nos foi enviada amostra alguma desta bebida afim de ser analisada. Usa-se sómente nos distritos de Lourenço Marques e Gaza.

Outros Frutos.—Fabricam os indigenas vinhos de varios outros frutos que, segundo ao regiões, podem obter em certa quantidade, mas essa fabricação é sempre limitada pela pouca abundancia des frutos de que podem dispor. Umas vezes são frutos de plantas originarias de outras regiões e já aclimatadas em Africa outras vezes são frutos de plantas proprias dessas regiões.

Entre os primeiros temos:—

Banana: Fruto de *Musa sapientum*, Lin.
Laranja: Fruto de *Citrus aurantium*, Lin.
Manga: Fruto de *Mangifera indica*, Lin.
Melancia: Fruto de *Citrullus vulgaris*, Sharard.
Goiaba: Fruto de *Psidium pomiferum*, Lin.

Como todas estas plantas necessitam de cuidados de cultura e são tambem aproveitadas para a alimentação, nunca o indigena dispõe delas em grande quantidade e por isso os vinhos e aguardentes que com elas prepara são sempre em quantidade limitada.

Entre as plantas peculiares á flora da Provincia e de cujos frutos o indigena ás vezes fabrica tambem bebidas, temos:—

Sandjahua ou Machanjahua: *Popowia caffra*, Harv. and Sond, frutos pequenos, da côr e dimensões da cereja.

Matite: *Uvaria caffra*, E.M., frutos semelhantes na côr e tamanho á azeitona.

Tinhnuebe: *Mimusops obovata*, Sond, fruto amarelado de sabor semelhante ao da uva.

Tole: *Mimusops caffra*, E. May, pequeno fruto alaranjado.

Mecurre: *Eugenia cordata*, Laws. fruto da côr e tamanho da azeitona.

Ungo: *Landolphia kirkii*, Dyer, fruto com aspecto e tamanho do pessego.

Estes varios frutos, todos mais ou menos adocicados, são aproveitados pelos indigenas, quando os podem obter em quantidade sufficiente, para a preparação de bebidas alcoolicas fermentidas (raras vezes) e distiladas (quasi sempre). De nenhuma dessas bebidas obtivemos amostras para a analise. A pouca abundancia dessas plantas e a sua distribuição por zonas limitadas, faz com que o fabrico dessas bebidas seja bastante restrito e constituam especialidades apreciadas pelos bons bebedores.

Não é esta com certeza a lista completa de todos os frutos que os indigenas aproveitam para o fabrico das suas bebidas alcoolicas, mas sómente daqueles de que podemos obter informações, podendo dizer de uma maneira geral que qualquer fruto que contenha assucar, é por ele aproveitado para pisar, fermentar e colocar no alambique para distilação.

Uputo.—Bebida fabricada durante todo o ano pelos indigenas com milho (*Zea mais*, Lin., " mafaca " dos indigenas), mapira (*Sorghum vulgare*, Pers., " mahila " dos indigenas), mechueira (*Pennisetum typhoideum*, Rich., " mala," " mahinde," ou " mahúa " dos indigenas).

São, todas, sementes que o indigena pode guardar durante todo o ano e que emprega para a sua alimentação e para a perparação de bebidas alcoolicas.

O processo de preparação desta bebida é o seguinte: a semente a empregar é reduzida a pó fino num pilão e fervida numa panela juntamente com cinco ou seis vezes o seu peso de agua. Logo que se dá a ebulição a panela é retirada do lume e guardada por vinte e quatro horas ao fim das quaes o liquido é submetido a nova fervura e, depois de arrefecido, adicionado dum pouco de *fermento* e deixado em repouso por um ou dois dias. Ao fim deste tempo o liquido é coado e está pronto a ser bebido.

Para a preparação deste vinho o indigena emprega geralmente um *fermento* preparado com mapira ou mechueira. Este fermento é obtido deixando num logar fresco, durante dois dias, a mapira ou mechueira em grão numa vasilha com alguma agua e coberta com folhas verdes. Ao fim desse tempo a mapira está grelada e o indigena retira-a da agua, põa-a a escorrer e depois redu-la num pilão a uma massa, a que dá o nome de " mirrobo," que guarda para utilisar para fermento do vinho. Em logar de fazer fermento de mapira emprega tarbem o indigena ás vezes fermento feito de milho, mas prefere o de mapira, pois que o vinho feito com o fermento de milho produz fortes dores de cabeça durante a embriaguez.

O indigena ingere grandes quantidades deste vinho. Póde ingerir até 15 ou 20 litros por dia. Ao fim da ingestão de cinco ou seis litros começa a embriguez. Esta é demorada e geralmente prolonga-se durante varios dias mediante varias doses de bebida. Este vinho é consumido pelos indigenas de toda a Provincia dando-lhe no Sul o nome de Uputo e no Norte o nome de Otéca. Pódem-no preparar durante todo o ano com o cereal que

guardam, mas o seu fabrico é maior logo depois das colheitas, isto é, nos mezes de Agosto, Setembro e Outubro.

O Uputo é um vinho de fraca graduação alcoolica. Nas amostras que examinámos, encontramos graduações de 4°, 8 (amostra n° 11), 3°, 9 (n° 12), e 2°, 4 (n° 21). Tambem são pouco abundantes os productos de distilação que se encontram: ausencia de furfurol, vestigios de aldehydos, ethers e alcooes superiores em pequena quantidade.

Otéca.—Por este nome designam os indigenas do Norte da Provincia as bebidas fermentadas feitas com farinha de mandioca, milho ou mapira, correspondentes portanto ao que os indigenas do Sul designam pelo nome de Uputo.

A mandioca, *Manihot utilissima*, Pohl, " mi-pau " dos indigenas é a mais empregada das trez plantas acima referidas para produzir a Oteca. É da raiz que os indigenas extraem a farinha com que preparam as bebidas fermentadas.

A mapira, *Sorghum vulgare*, " mahila " entre os indigenas, é uma graminea cujo fruto é aproveitado para produzir directamente a otéca de mapira, e outras vezes para preparar sómente o fermento para produzir as otécas de mandioca e de milho.

O milho, *Zea mais*, " mafaca " dos indigenas é, como a mandioca muito empregado para produzir as otécas.

O processo de preparação destas bebidas é identico ao que é empregado para a preparação do Uputo. O fermento é geralmente feito com o grão de mapira posto a germinar durante cinco ou seis dias.

A analise quimica revelou-nos para estas bebidas uma graduação alcoolica fraca: 4°, 6 (amostra n° 39), 3°, 6 (n° 40) e 2° (n° 45); pequena quantidade de aldehydos, ausencia de furfurol, quantidade relativamente pequena de ethers e alcooes superiores.

Estas bebidas são empregadas principalmente nos mezes de Junho a Outubro, época das colheitas, quando ha cereal em abundancia, mas o indigena póde prepara-las durante todo o ano com o cereal que guarda até nova colheita.

Pombe.—Nome porque algumas tribus indigenas do Norte e Centro da Provincia designam a bebida fermentada feita com a farinha de mandioca, de milho ou de mapira. O processo do fabrico é identico ao descripto para a preparação do Uputo e da otéca. O fermento usado é geralmente preparado com grão de mapira.

A amostra analisada, n° 46, revelou-nos uma fraca graduação alcoolica (3°, 9), ausencia de aldehydos e de furfurol, mas certa quantidade de ethers e alcooes superiores.

A quantidade que produz a intoxicação alcoolica varia de um a trez litros e dura umas seis horas. É bebida que o indigena produz durante todo o ano.

Sura.—E uma bebida fermentada que os indigenas preparam com a seiva do coqueiro, *Cocos nucifera*, Lin., " coco " dos indigenas.

O processo de preparação é o seguinte: faz-se uma incisão no pedunculo do cacho da palmeira e coloca-se uma pequena vazilha de modo que receba a seiva que escorre pela incisão feita. Este liquido é depois vasado para panelas ou anchoretas colocadas em sitio fresco e onde passa a fermentar. Ao fim de algum tempo está pronto a ser ingerido. A embriaguez só se manifesta depois da ingestão de cinco ou seis litros de liquido e dura geralmente umas trez a cinco horas.

Esta bebida póde ser obtida durante todo o ano no Norte e Centro da Provincia e era geralmente vendida ao indigena pelos proprietarios dos palmares. Actualmente a exploração comercial da sura está proíbida por uma lei de 1920.

A analise quimica revelou-nos graduações alcoolicas fracas: 3°, 3 (amostra n° 36), 6°, 5 (n° 41) e 2°, 9 (n° 44); ausencia de furfurol, pequena quantidade de alcooes superiores mas ethers e aldehydos em certa quantidade.

Como o coqueiro se cultiva quasi exclusivamente na faixa litoral da Provincia, são os indigenas do litoral que consomem a sura extraida desta planta. Os indigenas de alguns pontos do interior extraem sura duma palmeira brava, a *Hyphaene crinita*, Gaertn, " mahanga " ou " guehó " dos indigenas. O processo de obtenção é semelhante ao que se emprega para o coqueiro: corta-se o espique na sua parte superior e pla incisão feita escorre a seiva que se acumula num pequeno recipiente, geralmente uma casca de massala, adrede colocada. O indigena costuma proteger o conjunto, contra a evaporação, chuva e cacimba, com um entrançado de folhas de palmeira.

Xichemelane, *Chuaia-uaia*, ou *Sópe*.—Bebida fermentada extraida da cana de assucar, *Saccharum officinale*, Lin., " môa," " muba " e " si-môba " dos indigenas.

O sumo da cana é extraida por meio de esmagamento, recolhido em vazilhas e posto a fermentar. Ao fim de 24 horas está pronto a ser consumido.

Em virtude dos cuidados necessitados pela cultura da cana de assucar, esta bebida não é usualmente preparada pelos indigenas, mas sim pelos europeus que teem feito dela uma rendosa industria bastante explorada nalguns pontos da Provincia. Actualmente o seu fabrico está grandemente reduzido pela legislação vigente, orientada no sentido de acabar com ela definitivamente num prazo muito curto.

Um litro desta bebida é capaz de produzir a embriaguez que dura de trez a quatro horas.

A analise revelou-nos, nas duas amostras que obtivemos, uma graduação alcoolica relativamente elevada, 8°, 4 (amostra n° 1) e 10°, 3 (n° 13), conjuntamente com uma percentagem grande de aldehydos, ethers e alcooes superiores.

Aguardentes.

De todas as bebidas fermentadas que acabamos de estudar podem os indigenas fabricar aguardente. A sua produção está apenas condicionada pelo facto de poderem ou não dispôr dum alambique. Dado o gosto especial pelo alcool, ele dá sempre preferencia ás bebidas distiladas, muito mais ricas em produtos alcoolicos.

Contudo são poucas aquelas que, pela sua, generalisação a toda a Provincia e larga extensão de consumo, merecem um estudo detalhado, e só das mais usadas obtivemos amostras para analise.

Estudaremos as seguintes:—

Cajú.—O producto obtido pela fermentação dos frutos, pelo processo que atraz descrevemos, é lançado no alambique, distilado e a aguardente obtida está pronta a ser ingerida.

A analise quimica revelou-nos as seguintes caracteristicas: graduação alcoolica 18°, 1 (amostra n° 24), 18°, 8 (n° 37) e 15°, 4 (n° 43), aldehydos em grande abundancia, furfurol em certa quantidade, ethers e alcooes superiores em dose elevada.

É uma das bebidas mais empregadas pelo indigena para se embriagar, o que é devido á abundancia do cajueiro do Norte ao Sul do Provincia. Felizmente que só é consumida durante o periodo de frutificação da árvore, de Desembro a Janeiro, época em que a população de povoações inteiras, homens e mulheres, se encontra durante dias e dias sob a acção duma embriaguez permanente.

Mandioca.—A aguardente é obtida submetendo á distilação o producto proveniente da fermentação da farinha.

A analise revelou-nos uma graduação alcoolica não muito forte, 10°, 1 (amostra n° 3) mas uma quantidade grande de productos extrativos: aldehydos, furfurol, ethers e alcooes secundarios.

Partilha com o cajú a primasia do consumo entre os indigenas, com o inconveniente de poder ser preparada durante todo o ano e em qualquer época.

Ananaz.—A aguardente de ananaz é usada quasi exclusivamente no Norte da Provincia e entre os Ba-chopi (Gaza e Inhambane).

A analise revelou-nos a maior das forças alcoolicas de todas as bebidas estudadas: 24°, 4 (amostra n° 38). A este numero devemos juntar a ausencia de furfurol, certa quantidade de aldehydos e a presença de ethers e alcooes superiores em abundancia.

O consumo desta bebida não é muito grande entre os indigenas devido a que só póde ser preparada na época da frutificação da planta e ainda a que esta exige alguns cuidados de cultura e o fruto é muito procurado como alimento.

Tendo concluido o estudo das principaes bebidas de que obtivemos amostras, só nos resta frizar os inconvenientes que adveem para o desenvolvimento e faculdades de trabalho da raça indigena devidos ao abuso dessas bebidas.

Parece hoje em dia provado que as varias bebidas fermentadas preparadas pelos indigenas teem um certo poder antiscorbutico pelas *vitaminas* contidas nos cereaes germinados e nos frutos empregados para a fermentação. A quantidade de alcool que essas bebidas fermentadas conteem é relativamente pequena, de modo que quando ingeridos em dose moderada só devem ter um efeito estimulante sobre o sistema nervoso.

Por estas razões poderá talvez parecer defensavel a permissão dada ao indigena para poder fabricar e consumir, em quantidade moderada, *bebidas fermentadas* feitas quer de cereaes quer de frutos, contudo a impossibilidade de fiscalisação e a tendencia innata do indigena para a embriaguez fazem com que seja perigoso estabelecer essa permissão.

O principal factor do vicio da embriaguez, entre os indigenas, está no alambique e na distilação das bebidas fermentadas para a obtenção de aguardentes de pessima qualidade, com uma graduação alcoolica relativamente grande e carregadas de produtos distilados bastante toxicos e depressores das faculdades intelectuaes. Por essa razão a *distilação* das bebidas fermentadas deve ser inteiramente proibida aos indigenas e a contravenção dessa disposição fortemente castigada.

Summary in English.

A Contribution to the Study of the Alcoholic Drinks made by the Natives of Moçambique.

A certain number of alcoholic drinks made by the natives of Moçambique have been tested and investigated in the Chemical Laboratory at Lourenço Marques. At the same time valuable information has been obtained from the authorities all over the country about the processes of preparing these drinks, and their action upon the natives.

The results may be summarised as follows:—All the drinks made by the natives may be classified into two groups: wines and spirits. The wines are made from different kinds of fruits and flours submitted to a process of fermentation. The spirits are obtained by distillation of the wines made by fermentation.

The fermentation of fruits is accomplished by taking the juice of the fruit and leaving it for a period of two or three days in a cool place. The fermentation of flours is accomplished by adding to a suspension of flour in water, previously boiled, a certain amount of ferment prepared with germinated cereal.

This mixture is put in a cool place and after three or four days it will be ready for use.

The distillation of the spirits is performed by heating the fermented liquid in a still made in a rudimentary manner, and collecting the distillate.

The wines most used by the natives of this Province are: in the South the *Uputo*, made from flour of maize or mapira; the *Cajú*, made from fruits of *Anacardium occidentale;* and the *Bimbe*, made from fruits of *Garcinia livingstonei.* In the north, the *Sura*, made with the sap of the palm tree, and the *Otcca*, made with the flour of maize or manioc, are used.

As regards the spirits, the most used are those made with *Cajú*, *Manioc* and *Pineapples*.

Chemical analysis has shown that the alcoholic strength of the wines is always low, between 2 and 10 alcoholic degrees. For the spirits the strength is much higher—25 for the pineapple spirit, which was the highest found. Most unfortunately, from the majority of these drinks there are by-products of alcoholic fermentation accompanying the ethyl alcohol, which products are most harmful to the human organism. These products are furfurol, aldehydes, ethers and the high-grade alcohols. Some of the wines also have these products in fair amount; all the spirits, above mentioned, have them in large quantities. For this reason it is not surprising to find that alcoholic intoxication is nearly always accompanied in natives by symptoms of great nervous depression.

At the same time, we know that the wines made by fermentation of flours and fruits have a good influence on the body of the native, when taken in moderate quantities, and are a sort of food, because of the alimentary principles contained in them. There is also the current opinion that the vitamines included in the germinated corn and fruits have an antiscorbutic action for the native people.

For these reasons I think that the three following conclusions can be drawn from my work regarding the measures to be taken to combat alcoholism amongst the natives:—

1. The native may be allowed to make his own wines obtained by fermentation. The selling of them must be forbidden and intoxication must be punished.
2. We must forbid the use of the still by natives for the making of spirits.
3. We must strictly forbid the making of alcoholic native drinks by white people for sale to natives.

Analyse chimica das bebidas indigenas enviadas pelas varias Circumscripções da Provincia de Moçambique.

	INHAMBANE.		MAPUTO.		MAGUDE.			LOURENÇO MARQUES.		
	1 V. Canna.	3 Ag. mandioca	10 Bimbe	11 Uputo.	12 Uputo.	13 Canna.	14 Bimbe.	21 Uputo.	22 Bimbe.	23 Caju.
Densidade ..	—	—	—	—	—	—	—	—		
Acidez (em ac. oleico) ..	—	—	—	—	—	—	—	—	—	—
Força alcoolica	8°·4	10°·1	4°·8	4°·8	3°·9	10°·3	4°·3	2°·4	10°·6	4°·3
Aldehydos ..	† † †	† † †	—	† †	—	† † † † † †	† † †	†	—	†
Ethers ..	†	† †	†	† †	† †	† †	† † † †	† †	† †	† †
Alcooes superiores ..	† † †	† † †	† †	†	†	† † †	† † †	† †	† †	†
Furfurol ..	—	† † †	—		—		—	—	—	—
Extracto secco ..	1,150	0,088	1,896	2,362	3,510	2,416	2,432	4,674	2,868	1,704
Extracto calcinado ..	0,154	0,008	0,250	0,124	0.302	0,218	0,298	0,228	0,058	0,080

	INHAMBANE.		MAPUTO.	ANGOCHE.				MOEBASE.					
	24 Ag. Caju.	30 V. Caju.	36 Sura.	37 Ag. Caju.	38 Ag. Ananaz.	39 Oteca.	40 Oteca.	41 Sura.	42 V. Mandioca.	43 Ag. Caju.	44 Sura.	45 Oteca.	46 Pombe.
Densidade ..	—	—	—	0.975	0,960	1.000	1.000	0,990	1,000	0,970	0,995	1,000	1,000
Acidez (em ac. oleico) ..	—	—	—	—	—	—	—	—	5·78	0·05	3·10	4·79	6·20
Força alcoolica	18°·1	5°	3°·3	18°·8	24°·4	4°·6	3°·6	6°·5	2°	15°·4	2°·9	2°	3°·9
Aldehydos ..	† † † † † †	—	† † †	† † † † † †	† † †	† †	—	† † † † † †	† †	† † †	† †	† †	†
Ethers ..	† † † †	† † †	† † †	† † †	† † † †	† †	† † †	† † † †	† †	† †	† †	† †	† † †
Alcooes superiores ..	† † † † † †	†	†	† † † †	† † † † † †	†	† †	† †	†	† † † † † †	†	† †	† †
Furfurol ..	†	—	—	† † †		—	—	—	—	† †	—	—	
Extracto secco ..	0,030	1,744	1,848	0,004	0,008	2,780	2,710	1.426	3,758	0,014	1,070	3,072	3,996
Extracto calcinado ..	0,006	0,220	0,202	0,001	0,003	0,212	0,250	0,122	0,174	0,010	0,070	0,108	0,151

A determinação dos aldehydos, ethers, alcooes superiores e furfurol foi feita pèlos methodos colormetricos e a impossibilidade de obter colorimetros padrões obstou a que se podesse fazer a determinacao quantitativa exacta desses productos, limitando-nos á sua determinação comparativa entre as varias bebidas, designando por maior ou menor numero de † a quantidade maior ou menor dessas substancias. A sua ausencia foi designada pelo signal —.

A CONTRIBUTION TO THE STUDY OF HUMAN INTESTINAL PARASITOLOGY OF MOÇAMBIQUE.

BY

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Read July 13, 1922.

AUTHOR'S TRANSLATION.

During my first year of service at the Lourenço Marques Bacteriological Laboratory, I have been able to record the following Entozoa:—

Entamoeba histolytica, *Giardia* (*Lamblia*) *intestinalis*, *Balantidium coli*, *Trichomonas intestinalis*, *Blastocystis hominis*, *Trichuris trichiura* (*Trichocephalus dispar*), *Ascaris lumbricoides*, *Oxyuris vermicularis*, *Ancylostoma duodenale*, *Strongyloides stercoralis*, *Schistosoma mansoni*, *Schistosoma haematobium*, *Taenia saginata*, and *Hymenolepis nana*.

I often found ova which, from the number of membranes, approached those of the *Taeniae*, but from the frill of the external membrane somewhat resembled those of *Ascaris*. Whenever I found ova which I was unable to identify, I asked for the total dejections of the patients, passed after the application of a vermifuge, in order to determine therefrom the corresponding worm. Up to the present, I have not been able to obtain them under such conditions. As they frequently appear, I hope to have the opportunity of completing this investigation.

I have found dejections with only one species of the above-mentioned parasites; but in the majority of cases I have found in the dejections of the same patient several parasites associated in almost all possible combinations, as may be seen from the following table:—

Negative diagnoses	76
Faeces containing one parasite only:	
Entamoeba histolytica	100
Trichuris (Trichocephalus) eggs	68
Eggs of Ascaris	27
,, ,, Ancylostoma	12
,, ,, *Schistosoma mansoni*	4
,, ,, *Taenia saginata*	3
,, ,, *Hymenolepis nana*	1
,, ,, *Oxyuris vermicularis*	1
Undetermined eggs	9
Giardia (*Lamblia*) *intestinalis*	17

Trichomonas intestinalis	4
Blastocystis hominis	1
Strongyloides stercoralis	3
	250

Faeces containing two kinds of parasites:

Entamoeba histolytica and eggs of Trichocephalus	6
,, ,, ,, ,, ,, Ascaris	10
,, ,, ,, ,, ,, Ancylostoma	1
,, ,, ,, ,, ,, *Schistosoma mansoni* ...	4
,, ,, ,, Trichomonas	1
,, ,, ,, Lamblia	4
,, ,, ,, *Blastocystis hominis*	1
Eggs of Trichocephalus and Ascaris	19
,, ,, ,, ,, Ancylostoma	25
,, ,, ,, ,, *Schistosoma mansoni*	5
,, ,, ,, ,, *Taenia saginata*	2
,, ,, ,, ,, *Hymenolepis nana*	2
,, ,, ,, ,, Undetermined eggs	3
,, ,, ,, ,, Trichomonas	2
,, ,, ,, ,, Strongyloides larva	1
,, ,, ,, ,, Oxyuris	1
,, ,, ,, ,, Lamblia	1
,, ,, Ascaris and Ancylostoma	4
,, ,, ,, ,, *Schistosoma mansoni*	2
,, ,, Ancylostoma and *Schistosoma mansoni*	3
,, ,, *Schistosoma mansoni* and *Balantidium coli* ...	1
Trichomonas and *Balantidium coli*	1
	98

Faeces containing three kinds of parasites:

Eggs of Trichocephalus, of Ascaris and Ancylostoma ...	16
,, ,, ,, ,, ,, ,, *Taenia saginata* ...	2
,, ,, ,, ,, ,, ,, Trichomonas ...	2
,, ,, ,, ,, ,, ,, Amoeba	4
,, ,, ,, ,, ,, ,, *Schistosoma mansoni*	1
,, ,, ,, ,, Ancylostoma and *Hymenolepis nana*	1
,, ,, ,, ,, Ancylostoma and *Schistosoma mansoni*	2
,, ,, ,, ,, Ancylostoma and Amoebae ...	1
,, ,, ,, ,, ,, ,, Strongyloides larva ...	1
,, ,, ,, ,, Amoebae and Lamblia ...	7
,, ,, Ancylostoma, of Ascaris and Strongyloides larva	1
,, ,, ,, ,, ,, ,, *Schistosoma mansoni*	2
,, ,, ,, ,, ,, ,, Amoebae	1
,, ,, ,, ,, *Schistosoma mansoni* and Strongyloides	1
	42

Faeces containing four kinds of parasites:

Eggs of Trichocephalus, Ascaris, Ancylostoma and *Schistosoma mansoni* ...	2
,, ,, ,, ,, Ancylostoma and *Schistosoma hæmatobium*	2
,, ,, ,, ,, Ancylostoma and Strongyloides larva ...	1
,, ,, ,, ,, Ancylostoma and Amoebae	4
,, ,, ,, ,, *Schistosoma mansoni* and Amoebae	2
,, ,, ,, Ancylostoma, *Schistosoma mansoni*, and *Taenia saginata* ...	1
,, ,, ,, Ancylostoma, *Schistosoma mansoni* and Amoebae	1
	13

Faeces with five parasites:

Eggs of Trichocephalus, of Ascaris, Ancylostoma, *Schistosoma mansoni* and Trichomonas	1
	480

As will be observed, there are cases when three or four very harmful parasites appear in the same individual, all of them demanding a more or less specific treatment. The therapeutics of the intestines, in tropical climates more than anywhere else (so common is its symptomatology), nowadays cannot be prescribed merely on the result of clinical observation, without the co-operation of the laboratory. Clinically one may surmise the presence of parasites, just as one may make a cannon at billiards with a strong push and without effect; with laboratory examination the chances of accurate diagnoses are much greater, and, more often than not, there is the certain identity of the pathogenic agent and consequently of the proper therapeutics to apply.

Adding those cases in which each parasite was found alone to those where it appeared associated with others, we come to the following figures in the 480 diagnoses made:—

480 Examinations of Faeces.

	Alone.	Associated.	Total.	Percentage of observations.
Entamoeba histolytica ...	100	47	147	30·6
Trichocephalus	68	112	180	37·5
Ascaris lumbricoides	27	75	102	21·2
Ancylostoma	12	71	83	17·5
Schistosoma mansoni	4	28	32	6·8
Taenia saginata	3	7	10	2·08
Hymenolepis nana	1	2	3	0·6
Oxyuris vermicularis	1	1	2	0·4
Strongyloides stercoralis ...	3	5	8	1·6
Lamblia intestinalis	17	12	29	6·05
Blastocystis hominis ...	1	1	2	0·4

Balantidium coli	0	2	2	0·4
Schistosoma haematobium...	0	2	2	0·4
Trichomonas intestinalis ...	4	7	11	2·29
Undetermined eggs	9	3	12	2·5

Naturally, these statistics were not made among the general population of the town, but refer to individuals for whom faecal examinations were requested, because of intestinal disturbances.

Besides the various and complex parasitic associations, I have recorded the following details, which are more interesting to my mind:—

(a) The rarity of rhabditiform larvae unassociated with ova of Ancylostoma. As regards the rhabditiform larva, seeing that the delay or interval between the passing of the dejection and its diagnosis is unknown, it becomes difficult, by simple examination, to ascribe them to Ancylostoma or even to *Strongyloides stercoralis*.

The simultaneous presence of ova of Ancylostoma and of rhabditiform larvae would suggest sometimes that they are phases of the same parasite. On every occasion, however, when rhabditiform larvae appeared, I made cultures from the dejections, and in less than 48 hours, at the temperature of the laboratory, I found the typical sexual forms of *Strongyloides stercoralis*.

As the larvae are actively motile, which renders difficult the observation of the small and more characteristic details, I always employed, as for Lamblia, Trichomonas, Balantidium, etc., with great advantage the simple process of Brumpt of examining the faecal matter in a drop of saliva placed between the slide and cover slip, which, by almost paralysing the activity of the parasites, greatly facilitates the examination. For examining Ciliates and Flagellates, I found nothing better than the Burri method by means of India ink, or microscopical observation under dark ground illumination.

(b) In the urines, ova of *Schistosoma haematobium* appear with relative frequency. I only found them twice in the dejections. I immediately asked for new samples of the dejections and of the urine, separately, from the same patient, in order to ascertain whether they really belonged to the faeces or to urines which might have been mixed accidentally with the dejections at the moment of evacuation. Even among civilised persons one knows what precautions are necessary in order to defaecate without simultaneously urinating, and so one can easily understand that, where raw natives are concerned, one must even more suspect that the faecal matter may be mixed with urine.

On first impressions, it seems an easy condition to satisfy. But I can assert that, notwithstanding that I have been constantly asking the medical practitioners to endeavour that their clients send to the laboratory faeces unmixed with urine, it is not uncommon to receive them diluted with urine, with *Entamoeba histolytica* and other cellular elements in advanced cytolysis, not only to the prejudice of the diagnosis of dysentery, but causing us to ascribe to the dejections what in reality got there in the urine.

The urines from those two patients in whose dejections ova of *Schistosoma haematobium* were found also contained ova. On the contrary I failed to trace them in new samples of faeces from one of the same patients, which is very probable evidence that they belong exclusively to the urines. In the second sample of faeces from the other patient, I continued to find the ova of *Schistosoma haematobium*, which probably indicates that it was really a case of mixed bilharziasis, vesical and intestinal, or there is the possibility of the dejections once more becoming mixed with urine, due to lack of interest in complying with the scientific needs of the laboratory, both on the part of the native patient, which is not surprising, or equally on the part of the staff of the hospital wards, which is greatly to be lamented.

(c) Bearing in mind that it is much easier to find the ova of parasites in the faeces after centrifugalisation or enrichment by other means, than by direct observation, which must be more delayed and repeated, I lately have started making all the examinations of faeces after centrifugalisation by the Telemann-Langeron process. In the absence of metal screens with appropriate meshes, I sieve the dejections, emulsified in physiological serum, across four layers of ordinary surgical gauze. Notwithstanding this deficiency of material, which will soon be remedied, the advantages of the method of enrichment become evident in a most striking manner on noting the results of 141 examinations of dejections made simultaneously by direct microscopical examination and after being submitted to Telemann-Langeron centrifugalisation, though executed in a crude way.

	Direct examination.	With centrifugalisation.
Schistosoma haematobium	2	3
Schistosoma mansoni	11	18
Ova of Ancylostoma	17	56
Ova of Ascaris	38	39
Ova of Trichocephalus	29	92
Miracidium of *Schistosoma mansoni* ...	2	0
Rhabditiform Larvae	4	0
Entamoeba histolytica	26	0

The fact of having resolved systematically to centrifugalise the dejections to be examined, has not caused me, of course, to depart from making at the same time direct examinations, which alone can supply me with the diagnosis of entamoebae, larvae, intestinal ciliates and flagellates, presence of blood and pus globules, condition of digestion of foodstuffs, etc., as one may conclude from the final part of the present table.

I am well aware that by sufficient repeated microscopical observations one should eventually succeed in seeing what is possible with centrifugalisation, which also takes time and necessitates reagents. While direct microscopical observations, in the absence of parasitologists, have to be performed by a qualified medical man, the centrifugalisation can be performed by native assistants.

CONTRIBUIÇÃO PARA O ESTUDO DA PATOLOGIA OCULAR DE MOÇAMBIQUE.

(1º ANO DE CONSULTA EXTERNA NO HOSPITAL DE LOURENÇO MARQUES, 1921-22).

POR

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Encarregado da clinica oftalmologica do Hospital Miguel Bombarda, Lourenço Marques.

Lido em 13 de Julho de 1922.

Começou esta consulta a ser procurada pelo publico em principios de Julho de 1921 e o seu registo a ser feito a partir de 15 do mesmo mês, ou sejam até ao fim do primeiro semestre de 1922, *onze meses e meio.* Nestes onze meses e meio de consulta d'olhos para indigenes, tirei do registo clinico os seguintes dados de estatistica:

Numero de tratamentos e exames feitos	5,141
,, ,, doentes que consultaram pela 1ª vez ...	374
,, ,, intervenções cirurgicas	71

A consulta externa foi marcada só para as terças, quintas e sabados; mas os casos agudos, necessitando tratamento seguido, eram tão frequentes que reconheci a conveniencia de atender os doentes todos os dias; e a consulta passou de facto a ser diaria, com uma media de 10 a 25 doentes. Os 5,141 exames e tratamentos feitos, nos 11½ meses dá uma media mensal de cêrca de 447 e diaria de 15.

Nos 374 doentes atendidos fiz os seguintes observações:

(A)	Afecções das palpebras	34
(B)	,, da conjunctiva	148
(C)	,, do aparelho lacrimal	2
(D)	,, da cornea	98
(E)	,, da esclerotica	1
(F)	,, da iris	14
(G)	,, do cristalino	21
(H)	,, do fundo do olho	16
(I)	,, do globo ocular total	14
(J)	Exames de refracção para escolha de oculos	57
(K)	,, ,, ,, de olhos normaes	9
		414

Decompondo seperadamente cada um dos grupos de doenças das 10 primeiras alineas anteriores, encontramos:

(A) Afecções das palpebras:

(a) Fleimões das palpebras superiores	2
(b) Triquiases	4
(c) Furunculos	4
(d) Bleferites ou blefero-conjunctivites	9
(e) Terçóes e chalazeons	15
	34

(B) Afecções do aprelho lacrimal:

(a) Dacriocistite flegmonosa	1
(b) Dacrioadenite	1
	2

(C) Afecções da conjuntiva:

(a) Conjunctivites agudas de bacilos de Weecks ...	54
(b) ,, subagudas diplobacilares ...	38
(c) ,, granulosas	15
(d) ,, gonococicas	13
(e) ,, difttericas	1
(f) ,, Primaverís	2
(g) ,, Fuliculares	2
(h) ,, cronicas	4
(i) Queimaduras quimicas	2
(j) Hamorragias subconjunctivaes	6
(k) Pterigeons	5
(l) Xerosis	3
(m) Pingueculas	2
(n) Corpos extranhos	1
	148

(D) Afecções da cornea:

(a) Opacidades cicatriciaes	22
(b) Corpos extranhos	31
(c) Estafilomas	1
(d) Feridas traumaticas	7
(e) Queratites ulcerosas	12
(f) ,, parenquimatosas	4
(g) ,, punctata	1
(h) ,, leprosas	2
(i) Querato-conjunctivites flictenulares	18
	98

(E) Afecções da esclerotica:	
(a) Episclerites	1
(F) Afecções da iris:	
(a) Irites e irido-ciclites	13
(b) Nevus	1
	14
(G) Afecções do cristalino:	
(a) Cataractas senis	15
(b) ,, traumaticas	1
(c) ,, diabeticas	1
(d) ,, Complicadas	3
(e) Subluxação do cristalino	1
	21
(H) Afecções do fundo do olho:	
(a) Nevrites opticas	4
(b) Atrofia dos nervos opticos	3
(c) Choreoretinites	6
(d) Ambliopias toxicas	2
(e) Emeralopia essencial	1
	16
(I) Afecções do globo ocular total e da orbita:	
(a) Panoftalmites	2
(b) Atrofia do bulbo ocular	7
(c) Traumatismo com ou sem perfuração	3
(d) Corpo extranho intrabulbar	1
(e) Glaucoma cronico	1
(f) Tumores da orbita	2
	16
Intervenções cirurgicas:	
(a) Extirpação de chalazeons	4
(b) Operação de trichiases	2
(c) Abertura de fleimões das palpebras superiores e de terçòes	8
(d) Excisão de pterigeons	4
(e) Extirpação do saco lacrimal	1
(f) Extracção de corpos extranhos da cornea ...	30
(g) ,, ,, ,, ,, ,, conjunctiva ...	1
(h) ,, ,, cataractas senis	10
(i) .. .. diabeticas	2
(j) Discisão de cataractas secundarias	2
(k) Iridectomias opticas	5
(l) Exentrações do bulbo ocular	2
	71

Atraz fica relatado o movimento que houve no primeiro ano de consulta d'olhos, trabalho exclusivamente meu, sem auxilio de enfermeiros, nem outras despesas de instrumental cirurgico e de pensos alem de meia duzia de gramas de medicamentos e uns quilos de algodão.

D'uma rapida leitura do registo clinico deste ano de consulta, pareceram me dignos de especial menção, por motivos varios, os casos seguintes:

(*A*) *Conjunctivite vernal:*

Não registei caso algum em indigenas. Encontrei-a apenas em dois portugueses de vinte e tantos anos de edade, recentemente chegados da metropole, com volumosas granulações tipicas nas conjuntivas tarsicas superiores.

Ambos notaram que a doença se havia agravado no mar, durante a viagem.

Rebeldes á terapeutica nos climas temperados, anualmente peorando na primavera e melhorando no inverno, devem naturalmente tambem ser influenciadas pelos factores climaticos locaes. Estou seguindo estes dois casos.

(*B*) *Conjunctivites gonococicas:*

Apareceram entre a população indigena numa proporção bastante elevada. Tratei 13 casos com gonococos no exame bacteriologico da secreção conjunctival, dos quaes 12 em creanças indigenas e 1 num europeu adulto, com habitos quasi cafreaes.

Como na Europa, mostrou-se muito menos grave nas creanças (as 12 curaram sem complicações) do que nos adultos (no unico caso tratado houve perfuração da cornea, com perda total da visão desse olho. O outro ficou ileso por ter sido isolado logo no começo por meio de um vidro de relogio colado com adesivo e colodio).

(*C*) *Querato-conjunctivites impetiginosas:*

Tão comuns nas clinicas oftalmologicas europeas, atacando os individuos da primeira edade, de temperamento linfatico-escrofuloso. Arrastam-se aqueles doentinhos, com inumeras recaídas, meses e meses, pejando as enfermarias e consultas d'olhos, interminavel tormento dos medicos oculistas e da pobre familia.

Até hoje registei aqui apenas uns ligeiros casos de querato-conjunctivites flictenulares, de curta evolução e muito mais benignas de que aqueles teimosos estados fotofobicos que com tanta frequencia encontrâmos na Europa.

(*D*) *Queimaduras quimicas conjunctivaes:*

Registei um diminuto numero de queimaduras conjunctivaes provocadas por sucos de acajú (?) ou de qualquer outro fruto ou vegetal. Pelo seu aspecto clinico (enorme edema com oclusão das palpebras, secreção conjunctival abundante, corneas ulceradas com a visão quasi abolida) á primeira vista impunham-se como conjunctivites purulentas gonococicas; e só o exame bacteriologico negativo e os anamnesticos fizeram pôr de parte aquela hipotese inflammatoria.

Para o tratamento tinha capital importancia este diagnostico diferencial, pois que as irritações quimicas conjunctivaes são

profundamente agravadas pelos adstringentes, um tanto causticos, usualmente empregados na terapeutica das conjunctivites gonococicas. Apliquei de preferencia as irrigações oculares tépidas com sôro isotonico das lagrimas (14 per cent.) para lavar a conjunctiva dos restos de substancia quimica irritante e arrastar para fóra a secreção conjunctival represada dentro dos olhos pela oclusão edematosa das palpebras; pachos quentes calmantes e descongestivos; e, quando havia lesões ulcerosas das corneas, umas gotas de soluto de atropina.

Salvou-se sempre grande parte da visão, sem que contudose conseguisse evitar opacidades cicatriciaes permanentes das corneas, por vezes estensas, diminuindo consideravelmente a agudesa visual definitiva.

(*E*) *Corpos extranhos oculares:*

Todos em operarios das oficinas dos C.F.L.M. salvo um redusido numero das serralheirias particulares.

Nos serviços de saude dos C.F.L.M. tentam sempre tirá-los. Só me chegam às mãos os que fôram de menos facil extracção; mas esses mesmo, numa cidade pouco industrial como ainda é Lourenço Marques, figuram na minha estatistica numa percentagem relativamente elevada.

(*F*) *Queratites leprosas:*

Encontrei somente dois doentes com lesões leprosas da cornea. Devemos notar que isto se passou numa consulta externa de Lourenço Marques onde os leprosos são isolados numa ilha pouco distante. Deve ser apenas um palido reflexo dos estragos oculares que naturalmente se encontrarão nas regiões da Provincia onde os leprosos abundam e não ha gafarias.

(*G*) *Conjuntivites granulosas ou tracomas:*

Encontrei-a com frequencia, mas na minha clinica particular, entre a colonia grega e sobretudo nos indo-britanicos, vulgarmente conhecidos pela alcunha de " monhé."

Tratei apenas dois Portugueses, que já a haviam trazido da Europa e dois indigenas, cujos casos nem eram clinicamente dos mais tipicos.

É um flagelo de consequencias gravissimas para a visão e não menos contagioso do que a lepra. Como n'esta, as pessoas de familia dos tracomatosos, principalmente as creanças, são as que correm mais risco de se contagiarem. Ainda como na lepra são as môscas, a falta de asseio e a comunhão de objectos de uso domestico (bacias e toalhas de rosto, lenços, etc.) os meios mais acusados de a transmitirem.

Com os actuaes tratamentos, embora não tendo efeitos seguramente curativos, seguidos com persistencia, chega-se na maior parte das veses a evitar as mais tremendas complicações e a conseguir um estado de cùra real ou aprente, menos propicio ao contagio da doença.

A profilaxia individual e colectiva do tracoma já está preocupando seriamente algumas nações.

Os Estados Unidos proíbem a entrada de emigrantes sofrendo de conjunctivite granulosa averiguada ou suspeita. As

companhias de navegação obrigadas a repatriar os passageiros rejeitados pelas auctoridades sanitarias dos portos norte-americanos, levam as suas prevenções, como por mais de uma vez tive ocasião de assistir em Lisboa, ao exagero de não deixar embarcar os emigrantes com destino á America do Norte em que o medico de bordo tenha encontrado a mais benigna afecção inflamatoria ocular, ainda que apresentem atestados passados pelos oftalmologistas portugueses garantindo a sua natureza não tracomatosa.

Em todo o litoral do Mediterraneo grassa o tracoma com maior ou menor intensidade.

No Egipto (onde por tal forma abunda que lhe adveio o nome de Oftalmia do Egipto, pelo qual tambem é conhecida esta enfermidade), já ha muito que o seu problema está sendo estudado e posto em equação.

Na Tunisia os Franceses resolveram encará-lo tambem a serio. Num relatorio dos serviços de saude afirma-se que mais de 90 per cent. das creanças das escolas estão contagiadas. Nos serviços de recrutamento fôram rejeitados mais de 50 per cent. dos mancebos por incapacidades derivadas do tracoma. Apesar dos cuidados em excluir os tracomatosos dos serviços publicos, o numero de pensões de reformados por aquela conjunctivite cronica é elavadissimo.

Entre nós as tabelas para avaliação das incapacidades por assim dizer, quasi não existem. A percentagem de compensação, por exemplo, que cabe a um sinistrado que tenha perdido em serviço os dois olhos é egual á que se dá a um outro que tenha ficado apenas com claudicação num membro, suficiente para ser abrangido pela tabela de incapacidades, mas que não o impede de exercer a sua actividade n'outros serviços não inferiormente remunerados. Em França, onde já a compensação de reforma é proporcional á desvalorisação funccional de orgão lesado, a perda de um só olho é avaliada em 30 por cent. e a perda total da funcção de ambos os olhos em 100 por cent. mais 25 per cent. para a pessoa que deve guiar e cuidar do cego. Sendo o tracoma uma afecção em marcha progressiva para a cegueira, comprehende-se que os já pesados encargos do tesouro se vão agravando constantemente com a evolução da doença.

Entre nós começa a haver motivos para receios imediatos e para aprehenções futuras se não adoptarmos algumas medidas profilaticas.

O numero de indo-britanicos por mim tratados na clinica particular é já relativamente avultado; mas leva-me a crer, refractarios como se me afiguram ser á terapeutica europea, que esse numero representa apenas uma parte infima dos muitos tracomatosos que deve haver já na Provincia.

Desconheço os habitos domesticos do indo-britanico. Ignoro se entre eles ha ou não comunhão de bacias e de toalhas de rosto ou mesmo se delas fazem uso. Sei é que tenho encontrado entre eles alem de bastantes casos graves em adultos, alguns outros em creanças que indubitavelmente já aqui deviam ter sido contagiadas. Os seus habitos de promiscuidade são propicios á propagação deste

terrivel flagelo; e se a Provincia continuar com a mesma indulgencia para com os emigrantes tracomatosos sem tomar, por razões humanitarias e economicas as necessarias medidas profilaticas, o problema do tracoma dentro d'algumas dezenas de anos, assumirá nesta colonia uma gravidade egual ou superior ao da lepra.

(H) Cataractas diabeticas num indigena novo:

Não quero referir-me ás cataractas senis, que podem aparecer em velhos com diabetes como nos velhos não diabeticos. O caso que venho relatar é o de um indigena de vinte e tantos anos com cataractas nitidamente diabeticas; isto è, em que a diabetes é tão grave, a turvação dos cristalinos tão rapida e o aspecto tumido tão distincto do das cataractas senis, que é impossivel deixar de admitir entre aquela diabetes e as cataractas uma relação de causa e efeito.

O estado do doente em questão quando se me apresentou na consulta externa do Hospital era o seguinte: Polidipsia, polifagia, poliuria magreira extrema, a pele sobre os ossos, e cego por duas cataractas diabeticas, pelo seu aspecto, levando-me a fazer-lhe a analise das urinas e que depois fui repetindo, encontrando sempre 350 a 400 gramas de glicose por 24 horas.

Em cirurgia geral é edeia mais ou menos assente considerar a diabetes grave como uma contraindicação para qualquer operação. Dada já a impossibilidade que ha na cirurgia ocular em aseptisar suficientemente o globo ocular para afastar seguramente os riscos da infecção operatoria, e atendendo a que estes graves diabeticos novos pouco tempo resistem á precépitada desnutrição que acompanha este estado diatesico agudo, não admira que a maior parte dos compendios de oftalmologia aconselhem em semelhantes casos a abstenção perante a gravidade e a quasi inutilidade da extracção de taes cataractas.

Num inquerito que já em Lisboa vinha fazendo, sobre os auspicios do erudito Professor Gama Pinto, por mim publicado na " Medicina Contemporanea " e que este caso mais vem confirmar, -sem negar a gravidade d'esta diabetes, chegava-se á conclusão de que, pelo contrario, o prognostico da operação de taes cataractas diabeticas, tanto sob o ponto de vista de complicações inflamatorias, como pela rapidez da cicatrisação e resultado final do beneficio visual, é muito mais favoravel do que na extracção das outras cataractas.

Em cada olho tive de fazer duas operações: a extracção do cristalino e semanas depois a discisão da chamada cataracta secundaria (capsula e restos de massas do cristalino opacificadas). Turo correu favoravelmente, sem complicações inflamatorias e a cicatrisação fazendo-se rapidamente. O doente entrou cego e teve alta com 2 pares de oculos, um de + 10 dioptrias positivas, com os quaes a visão era V egual 5/15; e outro de 14 dioptrias, para a visão de perto; o que já constitue um esplendido resultado, nem sempre obtido na extracção das cataractas senis.

A diabetes grave em individuos novos é uma enfermidade rara; e como nem todos esses raros diabeticos tem forçosamente

cataractas, comprehende-se quão raras elas sejam, e d'ahi a razão porque a este caso fiz referencia.

(I) Conjunctivites em vitelas com um diplococcus muito semelhante ao gonococcus:

O creador de gado que generosamente fornece vitelas para a preparação de vacina antivariolica, mandou-me pedir remedio para umas oftalmias, com caracter epidemico, que grassavam na sua manada.

Não consegui que ele me mandasse vitelas com a inflamação ocular em estado agudo. Em duas que entraram no Parque Vaccinogenico com um catarro ocular em via de cura, metendo um pouco a foice em seara alheia, fiz o exame microscopico do exsudado conjunctival, onde encontrei, ao lado de outras bacterias, bastantes diplococos extra e intracelulares com os caracteres morfologicos e de coloração do gonococcus de Neisser.

Não tinha então meios preparados para fazer culturas daquelas bacterias a fim de estabelecer o diagnostico diferencial entre gonococcus, diplococcus catarralis e outras bacterias semelhantes. Como me dizem que estas oftalmias se repetem, espero ter ensejo de completar este estudo.

Este rapido balanço ao meu trabalho num ano de clinica oftalmologica dá-me a convicção de algum serviço ter prestado quer em beneficio dos doentes, quer em informações oficiaes para avaliação de incapacidades visuaes e a consolação de ver dia a dia a consulta mais frequentada, sinal de que vae ganhando a confiança do publico.

Summary in English.

A Contribution to the Ocular Pathology of Moçambique.

This paper contains an account of 5,141 examinations for various eye diseases made in the Hospital Miguel Bombarda, Lourenço Marques, during a period of 11½ months, commencing in July, 1921. During this period, 5,141 cases were examined for treatment, 374 consultations were given, and in 71 cases surgical intervention resulted.

Affections of the eyelids numbered 24; of the conjunctiva, 148; of the lacrymal apparatus, 2; of the cornea, 98; of the sclerotic, 1; of the iris, 14; of the crystalline lens, 21; of the fundus, 16; of the entire eyeball, 14; tumours of the orbit, 2; differences of refraction, 57; normal eyes, 9. Analytical tables of each of the components of the above subdivisions are given.

Clinical and therapeutical notes are presented in connection with spring conjunctivitis, gonococcal conjunctivitis, conjunctivitis impetigo, accidents due to chemical agencies such as acrid plant juices, caustic alkalies, extraneous bodies in the eye, leprosy of the cornea, trachoma (which is rather frequent, and is considered in detail), diabetic cataract, and diplococcal and gonococcal conjunctivitis.

ON THE ZOOLOGICAL EVIDENCE RELATING TO ANCIENT LAND CONNECTIONS BETWEEN AFRICA AND OTHER PORTIONS OF THE SOUTHERN HEMISPHERE.

BY

JOHN HEWITT, B.A.,

Director of the Albany Museum, Grahamstown.

Read July 13, 1922.

In a recent number of this Journal (Vol. XVIII (1921), p 120) there appeared an important paper by Dr. A. L. du Toit on "Land connections between the other continents and South Africa in the past." Many writers have risked their reputations on this elusive subject. In modified form its literature takes us back to the dawn of human history, for, according to some students, the great island of Atlantis, recorded by Herodotus as Egyptian tradition, was actually a remnant of some old trans-atlantic land bridge. In modern times, zoologists and botanists alike have thought it necessary to invoke certain land connections between the continents in order to explain the facts of present-day distribution of animals and plants. It is true that the evidence submitted has been somewhat lacking on the geological side, yet the distributionists have clearly understood that such hypotheses are only permissible when no simpler explanation seems possible, and that an acceptable theory must have some geological data in its framework. Certain ancient land connections, such as that between Alaska and Northern Asia during the greater portion of the Tertiary period, are conceded by the most conservative authorities, but there is less agreement on the question of former connections between Africa and South America, or between Africa and Australia. A definite pronouncement on this problem, from the aspect of a leading geologist, is therefore of particular value to those of us who are interested in the study of zoogeography.

Dr. du Toit's views, based on those of Wegener, may be summarised as follows: A great southern continent, Gondwanaland, linked together South America, Africa, Madagascar, India, Australia, and even Antarctica, almost throughout the Upper Carboniferous, Permian, Triassic and Jurassic times. This hypothetical continent was not the vast area represented by Prof. Suess and many other writers. Instead, Dr. du Toit pictures the ancient land mass in much attenuated form, and the present continents as derived therefrom by forcible disruption of parts which gradually became widely separated. The other view involves no migration of continents, for the submergence of a vast land area in what is now the South Atlantic ocean is presumed to bring about the present continental conditions.

During Jurassic times, the connection between Australia and Africa seems to have been interrupted by a marine invasion,

which increased in the Cretaceous period, cutting off all direct connection between Africa and Australia; and, further, the Madagascar-Indian section became separated from Africa. In Cretaceous times, however, the Afro-American mass was still existing, although a breach was already developing in its northern portion. Ultimately, the South American and African coasts became completely separated towards the end of the Cretaceous. During the Tertiary period, whilst the several sections of Gondwanaland were moving rapidly apart, the elevated encircling folds, concurrently produced, brought new land connections into existence. The chief of these was one in Miocene times, between South America, Australia and New Zealand. There are some indications of another connection in the region of the line between Venezuela and Morocco, but there are no geological data to determine whether such connection took the form of an isthmus, or of a chain of islands of which the present day Cape Verde and Canary Islands are persistent relics. In Miocene times also, Northern Africa became linked to Asia and Europe by the emergence of the Iranian-Himalayan fold ranges, and Madagascar probably had temporary reunion with Africa.

Now, the geological data are certainly incomplete in respect to the periods which chiefly concern us here, namely, from the Jurassic to the Tertiary, and, as Du Toit says, some of the views expressed may be speculative, but zoologists have the satisfaction of knowing that the main outlines of the theory rest on palaeontological and geological considerations.

Another able geologist, Prof. E. H. L. Schwarz, has laid stress on the magnitude of the marine invasion during Cretaceous times, even to the extent of almost obliterating the land-surfaces of our continent, although this extreme view does not seem generally acceptable to geologists. Dr. Rogers says that "the area north of latitude 30° has not been under the sea since the remote period when animals and plants possessing structures preservable in sediments began to live."

A Recent Statement of Evidence submitted in support of an Ancient Land Connection between Africa and South America.*

The faunas of Africa and South America are on the whole essentially dissimilar, but in a few groups of animals there are some remarkable instances of affinity. The most striking case is that of the fresh-water fishes specified by Mr. C. T. Regan[9] as follows:—"South America has a very rich and varied fresh-water fish fauna: with the exception of the Osteoglossidae, a generalised and ancient group represented at the present day by a few remnants, it has not a single family in common with either North America or with Australia. On the other hand three South American families, Lepidosirenidae, Characidae [including our Tiger-fish], and Cichlidae [including the small fish known in the Transvaal as Kurpers], occur also in Africa, and the South American cat-fishes of the family Pimelodidae are clearly related to the Bagridae of Africa and India. If South America and

* See paper (9) of bibliography.

Africa were one continent in Cretaceous times, and the connection between them persisted until the beginning of the Eocene, these facts would be satisfactorily explained. . . . No known northern fossils can be referred to the African and South American families, and there is good evidence that the main distribution of fresh-water fishes changed but little during the Tertiary." Mr. Regan's explanation agrees with that suggested by Mr. Boulenger[3] some eleven years previously:—" As it is admitted by most geologists that a continuous land-communication probably existed across the Atlantic between South America and Africa up to the end of the Upper Cretaceous period, it is legitimate to explain the distribution of the Characinidae by such a bridge. This explanation tallies well with the fact, pointing to a severance from remote times, that although the Characinids of the Old and New Worlds show near affinity, no single genus is common to both." This authority hesitated to explain the Cichlid distribution in the same way, being more inclined to favour a northern origin for the family; still, he wrote: " The hypothesis of a South Atlantic land-communication in the Eocene has much in its favour, and when this is really established all difficulty in explaining the distribution of the Cichlidae will have disappeared."

Prof. Eigenmann, a leading American authority on South American fishes, has also expressed his opinion that fishes probably interchanged before the beginning of the Tertiary epoch between Africa and South America by way of a land-bridge between Guiana and Africa. He considered that North America has not contributed a single element to the freshwater-fish fauna of South America.

Evidence derived from the distribution of Arthropods has been epitomised by Mr. R. I. Pocock[9] as follows:—

" *Prototracheata.*—Peripatus is confined to tropical West Africa and tropical Central and South America and the Antilles. Opisthopatus is found only in Chili and Cape Colony [to which I may add also Natal and Lydenburg District, Transvaal].

" *Diplopoda.*—The Spirostreptid genus Orthoporus, which is of wide distribution in tropical America, is very closely related to tropical African, but not to tropical Asiatic millipedes.

" *Chilopoda.*—Parotostigmus occurs in tropical America and Africa, but not in tropical Asia. Scolopendra (S.S.) is mainly tropical and Central American, but in the Old World it has been recorded from the Cameroons, the Canary Islands, Arabia and Socotra.

" *Scorpiones.*—Of the three tropical American genera of the Scorpionidae, Opisthacanthus has its nearest ally in the tropical and South African Opisthocentrus [the present writer regards these two genera as identical]; and Diplocentrus and Oiclus are closely related to the Arabian and Syrian Nebo, the three together constituting the well marked sub-family Diplocentrinae.

" *Araneae.*—The Sicariidae (S.S.) range in America from Chili to Costa Rica, and are only found elsewhere in the world in South Africa. Of the three genera of Caponiidae, Nops and Caponina are tropical American, Caponia South African.

"In the case of the above-mentioned Arthropods, no reason can be assigned for their extermination elsewhere in the tropics, if they are the only extant representatives of genera, formerly widely distributed in the Northern Hemisphere."

Mr. Pocock also presented evidence in favour of a former trans-Atlantic connection from the distribution of the following groups of mammals:—Sirenia; the genus Trichechus; the Primates; and the Hystricomorph Rodents. The Manatees are restricted to the rivers and estuaries debouching into the Atlantic on the American and on the African sides. These animals do not venture out to sea, and no extinct representatives of the genus appear to be known from European or North American deposits to support the theory of its former extension into northern latitudes.

"The headquarters of the Hystricomorpha at the present time are South America, where they date back to the Upper Miocene. The only North American representative is the tree-porcupine, a late immigrant from South America. No extinct representatives have been found in early or mid-Tertiary strata in North America. But, in the Old World, alleged representatives of the sub-order, referred to the family Theridomyidae, occur in Eocene and Oligocene deposits in Europe, and at the present time several genera of Octodontidae occur in Africa, and the Hystricidae range from Africa through Southern Asia to Borneo. Until evidence for the existence of the group in early and mid-Tertiary or Cretaceous times in North America is forthcoming, it cannot reasonably be claimed that the South American forms are descendants from ancestors from the North."

"The past and present distribution of monkeys is tolerably similar to that of the Hystricomorph Rodents." Mr. Pocock did not think it probable that the resemblances between the Old and New World monkeys could be due to convergent descent from Lemuroids of the Old and New Worlds respectively.

Facts and Theories in Opposition to a Trans-Atlantic Hypothesis.

(*A*.) Referring solely to the mammalian data, Dr. C. W. Andrews[9] remarked that if a land-bridge had existed between Africa and South America in Tertiary times, one would expect a more extensive mingling of faunas than had actually taken place. Even in the Eocene, both continents must have had a varied mammalian fauna, yet it is only claimed that the Primates, the Hystricomorph Rodents, and perhaps some Insectivora, crossed from Africa to South America, no interchange in the opposite direction being known. The Primate evidence he rejected as being due to convergent evolution: the Hystricomorph Rodents, being all small animals, seem to have been very abundant, so that like rats and mice of to-day, they would be specially liable to accidental transport, and no land-bridge theory need be raised.

Professor Osborn[6] also considered that the geographical distribution of land mammals does not favour an Atlantis hypothesis,

and this authority mentioned only the Octodont rodents as affording possible evidence in favour thereof.

(*B.*) Dr. Smith Woodward[9] stated that "nearly all the vertebrates in South America which seemed to suggest a direct land connection with the Old World through Africa, were either (a) late-Tertiary immigrants from North America or (b) senile members of pre-Tertiary cosmopolitan groups." Further, "most of the resemblances in the faunas of the two countries usually noted are amongst animals of which the ancestry is entirely unknown. The only resemblances already explained by palaeontology were due to the survival in the two southern continents of remnants or refugees of formerly widespread faunas, which had become extinct in the more progressive northern hemisphere."

It is true that many animals now restricted to the southern hemisphere once enjoyed a much wider distribution, and probably certain resemblances in the faunas of South America and Africa can be best explained in the ways just indicated. As Dr. Woodward did not specify any instances to support his general statement, I shall merely mention several with which I am familiar.

(1) The Trogons constitute a very distinct group of birds. There are five genera in Tropical America, one in Africa—including the Narina Trogon, the most handsome of our forest birds—and two in the Indian and Malayan region. They occur also in Upper Oligocene deposits in France. Now the African genus Hapaloderma has apparently no special affinity with any of the American genera: on the other hand, it seems clearly related to the two Oriental genera inasmuch as these three differ from the American genera in possessing patches of soft naked skin around the eyes.

(2) For many years, certain peculiar spiders, comprising the small family Archaeidae, have been known only from South America (Mecysmauchenius) and Madagascar (Archaea). I have recently found them also in South Africa (*Archaea godfreyi*). This same genus Archaea occurred formerly also in Europe, being found in Baltic amber, which is stated to be of Oligocene age.

Thus, in both cases above-mentioned, there is undoubtedly an Afro-American affinity, but in neither case is it so strong as the affinity between African and other Old World members of the group.

(3) The freshwater tortoises of the family Pelomedusidae include only three genera, distributed as follows:—Podocnemis in South America and Madagascar, Pelomedusa in Africa and Madagascar, and Sternothaerus in Africa and Madagascar. In fossil form, Podocnemis is also known from England, Egypt, East Africa and India, in each case in Eocene deposits. Here, the distribution of Podocnemis at the present day, disconnected as it is in terms of any hypothesis, is alone sufficient to create suspicion of a much wider distribution in past times.

In these three instances, the fossil records in Europe point to a possibility of wide distribution in the northern hemisphere, at a period when Eurasia and North America were in free com-

munication: for during one portion of that period (Pliocene), it is known that North America became invaded by animals from Eurasia, including numerous antelopes and other ruminants.

Again, it is admitted that most of the resemblances usually noted are in animals of which the ancestry is entirely unknown. This is, indeed, a serious objection. It means that any deductions we may make from the facts of present-day distribution have to be regarded merely as theories. On the other hand, if we restrict ourselves to those animals of which some ancestor is known in fossil form, more than 99 per cent. of our fauna becomes excluded from consideration. The extreme imperfection of the geological record, so far as terrestrial invertebrates are concerned, is particularly marked in the southern hemisphere, where nothing comparable to the fossiliferous amber of Europe, nor to the rich shales of Florissant has been found; and in South Africa, even the Tertiary vertebrate fauna is almost unknown.*

(*C.*) Other recent criticisms are contained in a long and important paper by Dr. John D. Haseman.[7] He attempts to show on geological grounds that South America has not been connected with the Old World at any period. Thus he rejects the Gondwanaland theory *in toto*. And yet, to the author himself, the geological evidence does not seen absolutely prohibitive, for referring to Pilsbry's views in favour of a Brazilian-West African connection, based on a study of land-shells, he says:—"There is so much other geological evidence against the building up of a land mass across the great ocean depths of the South Atlantic, that we may consider Dr. Pilsbry's view highly improbable, *at least until some dynamic and more careful field studies have been made on the non-marine mollusca of the regions in question.*" (Italics mine).

The author affirms his belief that all the South American animals originally came from North American stock. The evidence of the freshwater fish is dismissed, inasmuch as he regards a certain North American Eocene fossil (Priscacara) as a Cichlid,, and indicating a northern origin for that family. However, an authority of much greater experience, Mr. C. T. Regan, emphatically denies this identification, stating that Priscacara actually belongs to the North American Centrarchidae. Dr. Haseman also indicates what he thinks is "another source of error in former interpretations, in ignoring the possibility of similar evolution of the identical ancestral stock in remote but similar environments."

Unfortunately, no instances of this are cited, but if it means that Afro-American affinities in any group of animals and Afro-Asiatic differences are explicable as a consequence of resemblances and differences of environment, the principle seems quite unduly extended.

(*D.*) Another criticism was contributed by Dr. C. J. Maury at the last meeting of the Association in Lourenço Marques

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* In his "Rift Valleys and Geology of East Africa," Prof. J. W. Gregory gives a list of vertebrates known from the Lower Miocene of Karungu Lake.

(1913). The authoress discredited the Tertiary land-routes between America and Africa, but seemed persuaded to believe in " a limited land-mass, not trans-oceanic, lying to the north and east of northern South America which supplied rock debris for building up the palaeozooics of Brazil, and the oldest rocks of Trinidad." Dr. Maury's special contribution to the evidence was derived from a careful study of the marine shells of Eocene rocks in Trinidad. She found there various very characteristic North American lower Eocene rocks at Pernambuco. The authoress laid great stress on the very close kinship of the North and South American Tertiary life; and on the other hand minimised the importance of the resemblances between the South American fossils and those of contemporaneous times of the Old World, as reported by many other writers. Her view rests on insufficient foundation, so far as land vertebrates are concerned; for the facts of mammalian palaeontology point to a long separation of North and South America during Tertiary times, North America exchanging at various times with Eurasia, but contributing nothing to the fauna of South America until the latter portion of the Tertiary period. This paper, through a misreading of the text in Osborn's " Age of Mammals " (p. 80), states that " Dr. Osborn in 1910 abandoned as a matter of imperfect record the theory of an Antarctic land-connection, even between South America and Australia. . . . He now believes that the greater part of the animals and plants of the southern continent are of northern origin, and that the evidence for Antarctic connections is probably explainable through distribution from the north. . . . It was a delight to find that these conclusions of Dr. Osborn, reached from a study of the vertebrates, should so harmonize with my own based on the invertebrates ! " But, unhappily, a perusal of the "Age of Mammals" shows that the distinguished American palaeontologist had no such views. The views attributed to him are (or were) those of Dr. W. D. Matthew. Osborn himself quite plainly tells us that " South America appears to have had late Cretaceous or early Eocene connections through Antarctica with Australia " (p. 78).

(*E.*) After all this, we read without surprise the views of Messrs. Nichols and Griscom[11] in their recent paper on the " Freshwater Fishes of the Congo." They conclude that the Characinids and Silurids entered Africa and South America independently from the Northern Hemisphere where they originated, despite the peculiar present-day distribution, and despite the fact that the authors believe in Gondwanaland as an Antarctic continent where certain more ancient groups of fishes took their origin (Dipnoi and Polypterids). This conclusion is based only on indirect evidence, chiefly the fact that the Cyprinidae, which are allies of the above two families, present clear indications of northern origin. The Siluridae, Characinidae and Cyprinidae are held to represent three consecutive waves of invasion from the north, the last wave failing to reach South America and Australia. As for the Cichlidae, they are held to have arisen independently from some tropical marine, Acantho-

pterygians. One portion of the argument is, however, doubtful. The authors suppose that Madagascar has been separated from Africa ever since the middle of the Secondary period, which, if true, would certainly imply a surprising antiquity for the Cichlidae, as a purely freshwater group. However, the presence of Cichlid perches in Madagascar can be well reconciled with a non-marine origin for all the modern genera, and with their specialised structure, clearly pointing to a fairly recent origin, on the hypothesis of a temporary Miocene connection between Africa and Madagascar, which is considered probable on geological grounds. The Cichlid fauna of Madagascar is actually very scanty, comprising only five species, whereas 288 species are recorded from Africa. This seems to favour direct spreading from Africa rather than an independent marine origin, especially as two of the three Malagasy genera are very closely related to Congo genera. Regan suggests that Madagascar "may have received its Cichlidae from Africa at a time when it was only narrowly separated from or even temporarily connected with that continent, and perhaps from India when the islands of the Indian Ocean were more extensive and a brackish-water fish might pass from one to another: this time can hardly have been later than the beginning of the Miocene."

(*F.*) There remains for brief consideration the remarkable paper on "Climate and Evolution" by Dr. W. D. Matthew.[14] The author approaches the subject as a firm believer in the "principle" of the permanence of the great ocean basins. This depends on the known facts in regard to Isotasy: the rocks underlying the oceans are heavier than those underlying the continents. Yet, in a footnote he adds the following:—"The suggestion of Bailey Willis that the present Isostatic compensation may be unusually complete must be borne in mind." Dr. Matthew will only admit that certain minor changes in the relations of land and sea have taken place. He cannot believe that Madagascar has had any direct land connection with Africa, for its fauna, he believes, might easily have been obtained through such accidental agencies as floating rafts. This agency is even exalted to explain the case of the South American Hystricomorph rodents, thus: "Oversea transportation from Africa appears to be the only reasonable interpretation of the evidence at hand." To many of us, such extensive transportation seems inevitable, and not even sufficient as an explanation of the Malagasy fauna. Besides Cichlid perches, which can tolerate brackish conditions, but are quite unknown in the sea, the fauna of Madagascar includes such freshwater animals as crayfish, frogs, tortoises and snakes, all related to freshwater animals of other regions, but intolerant of marine conditions. Not to mention the various mammals and land-tortoises, there are ground-dwelling frogs, like *Rana labrosa*, which seem ill-adapted for transportation on or in an ocean raft. Nor should it be assumed, as Dr. Matthew does, that the recent Aepyornis, a typical ratite bird, arrived on the island by flight, for the evidence that ostriches and their kin could ever fly is not at all satisfactory.

We conclude that a mid-Tertiary African connection, which provided a passage for swamp-dwellers, is a minimum estimate of the requirements. Even this leaves unexplained such anomalies as that of *Rana mascareniensis* which seem to imply a more recent connection, though only a very imperfect one in view of the absence of characteristic African mammals and birds from Madagascar.

The greater portion of the paper is devoted to a proof that nearly all the groups of mammals had their centres of dispersal in the northern hemisphere. This has to be conceded, but the extension of the principle to lower vertebrates and invertebrates must not be assumed. Matthew attempts to prove it in the case of certain toads—Cystignathidae, Discoglossidae and Pelobatidae, but his distribution data are quite wrong and the map very misleading (p. 296). According to the principle, the most primitive families should be southern, and their more specialised successors northern: but such is not the case, the southern Cystignathids being less primitive than the northern Pelobatids.

(*G.*) The last note I have seen on the problem of the tiger fish is one by Dr. C. R. Eastman,[11] in which he concludes that the ancestry of the modern Characinids may be traced back to Onchosaurus of the Cretaceous. One of the fossil species is found in the Upper Cretaceous of Egypt, and other representatives occur in Europe and North America. The identification is based solely on the characters of the teeth, which are very distinctive. Mr. Boulenger seemed to favour Eastman's conclusion, remarking that: "*Hydrocyon goliath* from the Congo has enormous shark-like teeth similar to fossil teeth occurring in the Upper Cretaceous, apparently indicating the existence of Characinidae in that epoch."

However, this seems to have been a mere guess, for Mr. Regan has recently informed me that, as shown by Stromer, the said teeth are actually rostral teeth of a sawfish!

Evidence for Regarding South America, Africa and S.E. Asia as a Single Zoological Region.

The occurrence of genetically related animals in Africa and South America may arise from various causes, but some former land-connection between the Old and New Worlds must be postulated: thus, the explanations fall into two main groups, some involving a trans-Pacific connection, apparently across Behring Straits, and others a trans-Atlantic connection, either north or south of the Equator.

Now, considering each case on its merits, we have to admit that various instances of Afro-American affinity seem explicable more or less well by either of the alternatives, and such inconclusive cases should be removed from consideration. I refer to very small and isolated groups of animals where fossil data is completely lacking. These may conceivably be remnants or refugees of formerly widespread faunas. Thus we eliminate the evidence of the Pipidae toads (Xenopus, Hymenochirus and

Pseudohymenochirus, in Africa, and Pipa in South America): also, that of the Caponiid and Sicariid spiders.

But in other instances mentioned by Mr. Pocock, the evidence, though admittedly incomplete in the total absence of palaeontological data, seems to me more favourable to an Afro-American land connection.

(1) The Ischnurine scorpions are to-day widely distributed, being known from the Ethiopian region, Madagascar, Oriental region from India to Papua, and from the northern part of the Neotropical region. There are four genera in Africa, one of them Opisthacanthus (about 10 species) occurring also in Madagascar (1 species) and in Central America (1 or 2 species). Another genus, Hadogenes, is confined to Southern Africa and Madagascar, whilst Iomachus occurs in Southern India and East Africa. Another genus, Hormurus, is Indian, Malayan and Australian, and there is a peculiar genus confined to Zanzibar, the Seychelles and Round Isle. Opisthacanthus is abundant and widespread in the Ethiopian region, extending through bush and forest districts from the neighbourhood of Capetown along the southern coast and far into the tropics of West Africa.

Thus the Ischnurine scorpions of Central America and of West Africa have a particularly close affinity, definitely greater than that between the West African and Malayan genera or between those of Asia and America. There is, moreover, nothing to show that Opisthacanthus represents the ancestral stock of the Ischnurine scorpions. The genus is certainly more generalised than either Cheloctonus or Hadogenes, the other South African members of this group, but not more so than the Oriental Hormurus. Critics may assume that Opisthacanthus has migrated through Eurasia and North America, when the climate of northern lands was milder than it is to-day, but the argument would be more convincing if the genus had a wider distribution in the Old World tropics, especially in view of its adaptability to widely different climates in Africa.

(2) The Onychophora is the group of terrestrial invertebrates commonly called Peripatus. There are two families, the Peripatidae and Peripatopsidae. A. H. Clark[8] divides the Peripatidae into two sub-families:—(a) The Eoperipatinae with two genera confined to the Malayan region and Tibet; and (b) the Peripatinae with three genera, one in French Congo (Mesoperipatus) and the other two in tropical America (Peripatus and Oroperipatus). The most primitive genus is Oroperipatus of South and Central America west of the crest of the Andes; and then follow in increasing order of specialisation, Peripatus of Eastern South and Central America, Mesoperipatus of French Congo, and finally the Eoperipatinae.

The other family Peripatopsidae also has two sub-families:—(a) The Peripatoidinae with three genera, one in Australia, New Zealand and Tasmania, one in Chili and Aconcagua, and one in South Africa (Opisthopatus), the latter being much more closely related to the American genus than to the Australian; and (b) the Peripatopsinae with one South African genus (Peripatopsis), and one in New Britain, New Guinea and Ceram.

Thus, in this group of animals, which is widely distributed in the warmer parts of the world, we have two striking instances of Afro-American affinity. In both cases, this is greater than the affinity between the African and their nearest Old World allies: further, the genera of Peripatidae seem to constitute a regular succession of forms, just as we should expect to find on the assumption that the Malay region, Central Africa and Tropical America were once connected up into one land mass.

Here I should add that, according to A. H. Clark, the Peripatopsidae most probably were distributed through Antarctica, which indeed seems very reasonable.

(3) The limbless amphibians composing the order Gymnophiona include 19 genera distributed through the tropics as follows:—Dermophis, a primitive genus, occurs in South and Central America (5), in San Thomé Island (1), in British East Africa (1), and in the Seychelles (1). Herpele, a somewhat specialised genus, occurs in Panama (1), in West Africa (3) and 1 in India (Assam): its nearest generic ally appears to be the South American Gymnopis. Uraeotyphlus, a primitive genus, has one species in West Africa, and two in India (Malabar).

Hypogeophis, a primitive genus, has one species in Zanzibar, and three in the Seychelles.

In addition, South and Central America have seven peculiar genera (two primitive, two somewhat specialised, and three scaleless and thus degraded): East Africa has three peculiar genera (two the most degraded of all, and the third also very degraded): the Seychelles have two peculiar genera (one primitive, and one somewhat specialised): West Africa has one peculiar but primitive genus: the Oriental region, including Malayan Islands and Indo-China, has two peculiar genera (one primitive, and one very degraded). Now all the scaleless genera (7) which are presumably degraded and recent, are strictly localised (three in America, three in Africa, and one in Travancore): from this it seems a reasonable inference that they at least have actually originated *in situ* from the local primitive stock.

Again, besides the three more or less widely distributed primitive genera above-mentioned, there are five others, apparently equally primitive but more localised, one ranging between Ceylon, Malay region and Indo-China, two in South America, one in West Africa and one in the Seychelles.

I have mentioned these details in order to emphasize the pronounced tendency to differentiate into local genera, not only in the most degraded groups, but also in the most primitive ones. This reduces the probability of such extensive migration as is implied in the theory that Herpele and Dermophis have migrated unchanged from Eurasia to the various localities they now occupy, as Wallace seemed to hold (see "Island Life," p. 404) from the scanty data that were then available.

Or, admitting the possibility, it still remains unexplained why the primitive Dermophis is absent from that region we should expect it to occupy on the migration hypothesis, namely, S.E. Asia.

Again, on the characters of the tentacle, the genera can be divided into three groups, each containing both primitive and degraded members. One result of this is to emphasize a special resemblance between Africa and America, for the largest section, comprising 10 genera, has no representative whatever in Asia, though it extends to the Seychelles. The second section of six genera is also represented both in America, Africa and the Seychelles, and in addition has Indian members. The smallest section of three genera is confined to the Old World, ranging from Africa to S.E. Asia. Thus we see that Africa behaves like a centre of dispersal for the whole group, and the relationship between the American and Asiatic elements is through the African fauna.

Some Evidence Relating to Connections Between the Southern Continents Through Antarctica.

Certain faunal resemblances have long been known between the extreme south of Africa and other portions of the southern hemisphere. These also might be regarded as last remnants of a primitive cosmopolitan fauna, which, owing to competition with more finished products of the same stock, have been driven southwards to the ends of the earth: or, another view would explain them in terms of a Gondwanaland theory. But, at any rate, it cannot be claimed for them, as some authorities may do for Peripatus and the Coecilians, that they left the northern hemisphere and persisted only in the tropics because the northern climate became too cold. Some advocates of the view first mentioned lay much stress on the occurrence of fossil leaves, supposed to belong to the family Proteaceae in the Miocene shales of Florissant in Colorado, this family at the present day being specially well developed in South Africa and occurring also in South America, Madagascar and Australia, but not at all in the northern hemisphere. Several eminent botanists have rejected these identifications as entirely untrustworthy, for leaf form alone is useless as a family character. Yet, Prof. T. D. A. Cockerell[10] does not hesitate to identify them thus, and tells us by way of verification that he took a certain lady up to some young plants of *Grevillea robusta* in a greenhouse, and asked without explanation, " Where have you seen that? " The reply came instantly: " In the shale." *She did not know why I asked, nor what the plants were: the impression made by the cut of the leaves was naive and immediate.* (Italics mine). If such is the evidence that Proteaceae were formerly northern, it can only be regarded as speculative. According to Dr. Schönland, the best authorities have treated all the identifications of southern plants in the Tertiaries of the northern hemisphere as worthless when based only on leaf characters.

A few instances of these southern resemblances are mentioned here.

(1) The freshwater fishes of the genus Galaxias occur in South Africa (restricted to Western Cape Province), the southern

extremity of South America, Falkland Islands, Southern Australia, Tasmania and New Zealand. They are comparatively primitive fishes according to Mr. Regan, and to that extent lend credence to the theory of Nichols and Griscom, that primitive freshwater fishes originated in the south, and the more recent fishes in the north. Some of the species resort to the sea for breeding purposes, and one species was originally described as marine, but this now seems to be incorrect. But, on such grounds apparently, they were regarded both by Boulenger and Regan as of marine origin. The South African species are quite distinct from any other, and there is no evidence that any species can cross wide oceans, although one species is common to South America and Australia. No fossils are known.

(2) The distribution of the freshwater Isopod Crustacean known as *Phreatoicus* is most suggestive. It occurs in the Western Cape Province (as made known by Mr. K. H. Barnard), in Australia, Tasmania, and New Zealand; in fossil form it has been described by Prof. Chilton[12] from Upper Triassic rocks in Australia. If this genus has been cosmopolitan during its prolonged life, it is a strange coincidence that the only place where it is known in fossil form is the region where it occurs to-day.

(3) The distribution of penguins is comparable to that of the genus Galaxias and the common species of the Cape has its nearest relative in the Falkland Islands. In the northern hemisphere penguins are quite unknown, either living or fossil, but they are known in fossil form from New Zealand and Patagonia, and are said to occur in early Tertiary rocks on Seymour Island. Thus we see that they have lived in the southern hemisphere for a very long period; and nothing can be stated in favour of their northern origin. This point needs emphasis because most writers who object to hypothetical land-bridges are obsessed with the idea that all the main groups of animals actually originated in the northern hemisphere.

(4) The distribution of the Cystignathidae (or Leptodactylidae), a family of toads, is peculiarly southern. Both in South America and in the Australian-Papuan region, they are the principal elements of the Anuran fauna. In addition, there is a single African genus, Heleophryne, which is only known from the Cape and Natal. Its relationships are not very decided, for in some respects it approaches the Australian genera and in others the South American. There is no evidence that any of the numerous genera belonging to this family have previously enjoyed an extensive distribution. Each one is confined to a single geographical region, and thus it seems likely that the generic differentiation at any rate has taken place in the southern hemisphere.

I have previously expressed the opinion, to which I still adhere, that the known facts are best explained on the assumption of former land connections between Australia, South Africa and South America through Antarctica. But Mr. G. K. Noble,[13] a recent authority, now assures us that there is no need for the Antarctic continent, nor for mid-Atlantic land-

bridges, thus:—" If we assume a (north) polar origin for the Pipidae, Hylidae, and Leptodactylidae, we escape the necessity for building any land-bridge." Thus we have to assume that there was once a Cystignathid fauna throughout the northern hemisphere and throughout Africa, which fauna has completely disappeared except for the southern species. There is no actual evidence in favour of this: it is offered merely as a simpler assumption than that of the objectionable land-bridge.

From the work of Mr. Noble and several earlier authorities, we realise that the family Cystignathidae is not really separable from the Bufonidae: these latter seem to be merely toothless Cystignathids. The toothed Cystignathid genera are to be regarded as primitive, and the various Bufonid genera as derived therefrom. The position may now be stated, as follows (excluding from consideration the genus Bufo, which is a recent and hardy cosmopolitan, except in Australia):

(a) There are 30 genera, some toothed and others toothless in South America, and two additional genera restricted to Central America, but except for one or two stragglers in Northern Mexico and Florida none of these extend their range beyond the neotropics, and of those genera which occur north of the isthmus " probably the majority have pushed their way northwards since the Panama connection " (G. K. Noble).

(b) There are 12 toothed genera and three toothless in Australia: two of the former and one of the latter occur in Tasmania: New Guinea has two toothed genera: the Indo-Oriental region has no toothed genera whatever, but has a number of toothless ones.

(c) Africa has a single peculiar toothed genus in the extreme south, and several toothless ones in the tropics, which latter, however, are not peculiar, but are represented also in the Oriental region and Australia: one of them (Pseudophryne) is derived directly from an Australian toothed genus and the other is hardly separable from it according to Mr. Noble. Madagascar has no representatives whatever.

One conclusion that may be lawfully drawn from these facts is that the toothless Bufonids now living in tropical Africa and some, if not all, of those in the Oriental region, have migrated there as such from the headquarters of the Cystignathidae in Australia: thus, they do not provide a missing link in the hypothetical world-wide distribution of the Cystignathidae.

A consistent theory must embrace also all other members of the sub-order Procoela, such as the families Hylidae and Brachycephalidae. Concerning the latter, nothing more need be said than that it is confined to the neotropical region, where no doubt it originated. The Hylidae, from structural considerations, have to be regarded as derivations of the Cystignathidae. The main features of their distribution are as follows:—Abundant in the South American and Australian regions; completely absent from the Indo-Oriental region and from tropical and South

Africa: except for the regions just mentioned, the genus Hyla itself is almost world-wide. This is exactly as we should expect of a moderately recent group on our theory of a centre of dispersal for the Procoela in or through Antarctica. There is one peculiar record which I do not profess to understand, namely, a species of Hyla in Abyssinia. Of this species, Mr. Noble says:—"It has very little in common with any Asiatic Hyla and but little more with any Australian or East Indian species. It agrees entirely with the maxima group of species from northern South America." It does not show close affinities with the species found in Syria and Palestine. The interpretation offered is as follows:—"It is very possible that the peculiar arrangement of the vomerine teeth characteristic of the maxima group (South American) could have had a parallel evolution in two such widely separated areas as Abyssinia and South America"; and further, "If this specimen actually came from Abyssinia, and we have no reason to doubt it, the genus Hyla must have existed in Africa for a very long time since *H. wachei* shows no close affinity to the eastern representatives of the genus." Thus we see how easy it is to explain the most intimate relationships between animals so remotely situated if only we are willing to make use of parallel evolution. My own inclination, in this case, is to suspect the premises, especially as the species is only known from the type specimen.

Conclusion.

The distribution data just considered seem most readily explained on the assumption of direct land connections between Africa, South America and Antarctica. On evidence which is similar, yet certainly more complete, rests the accepted theory of the Behring Straits connection. Yet, in view of the latter, some will prefer to assume a former world-wide dispersal followed by extinction over large areas: others will urge the claims of convergent or parallel evolution to explain particular resemblances: failing such explanations, accidental agencies of dispersal such as floating rafts may sometimes be invoked.

The credibility of the hypothetical Antarctic connection depends on the improbability of the total extinction of an original cosmopolitan stock throughout the world, leaving persisting remnants only in the extreme south. If it could be shown that the southern "remnants" are represented in the northern hemisphere by more highly-evolved members of the same stock, a northern centre of dispersal might be the most reasonable explanation. But such evidence is lacking in the cases we have considered. The extinction of all the northern elements of a fauna still living in the tropics is a known fact, being attributed to the frigid conditions which culminated in an extensive northern glaciation. But such conditions did not extend to the tropics at high altitudes.

The most important evidence for a direct trans-Atlantic connection between Africa and South America lies in the fact that, in several instances, the distribution in South America, Africa and Southern Asia is exactly what we should expect in a single

zoogeographical region. The genera do not divide themselves into groups in accordance with modern geographical conditions and the African elements constitute connecting links betweeen those of South America and Southern Asia. This, however, only occurs among comparatively ancient groups and I know of no parallel case in the mammals or birds.

It would suffice to explain such facts if the trans-Atlantic connection were limited to Mesozoic times. A direct Antarctic connection, even so far back as the Jurassic period, would explain the cases cited in this paper, except that of the penguins, for which, instead of actual land connections, we need only postulate closer proximity than occurs at present.

These connections receive considerable support from the geological side and thus we may reasonably recommend them as very credible.

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SOME PARASITIC PROTOZOA FOUND IN SOUTH AFRICA.—V.

BY

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Read July 13, 1922.

ABSTRACT.

In this paper are concisely recorded the results of my continued investigations on some parasitic Protozoa found in the South African sub-continent. The mode of work is as previously recorded, and the term " parasite " is used in a wide and general sense. The measurements of the organisms given were determined in the same manner as stated last year (this JOURNAL, Vol. XVIII, pp. 164-170) and as followed in previous communications of this series.

Attention may be drawn to the Protozoa found infecting cabbage, to the experimental infection of a rat with *Herpetomonas muscæ domesticæ*, to remarks on the natural occurrence of that flagellate, and to the finding of a Herpetomonas in soil. Also, the study of seasonal periodicity in the occurrence of Sarcosporidia has been continued, and the occurrence of Rhinosporidium in man in South Africa is recorded.

SARCODINA.

An interesting Amœba was seen one day in April in fresh rectal scrapings of a *Xenopus lævis*. The amœba, though not very active, had a wrinkled appearance, with numerous short pseudopodia, twelve to fifteen in number, one of which was somewhat filiform and longer than the rest. The body was 30μ to 35μ in diameter. The nucleus, which was excentric, had a relatively large karyosome. This amœba, though somewhat small, was of the *A. verrucosa* type, and may have got into the rectum of the frog from the outside viâ the mouth, and so may be an example of what has been called a " passenger."

A small amœba of the *A. guttula* type, but only about 12μ in diameter, was found in a cabbage stalk, somewhat strong smelling, taken from the fodder room of an animal house in Johannesburg. The organism was slow-creeping, showing one blunt pseudopodium only at a time. Unfortunately, the amœbæ were very few in number, and they were only observed in the fresh state.

A very few *Entamœba bovis* Liebetanz were found in the reticulum of an ox killed in Johannesburg. The amœbæ seen measured 20μ to 23μ in diameter, and one with an extended lobose pseudopodium measured 30μ across to the free edge of the pseudopodium. A cyst of this amœba measured about 18μ in diameter.

MASTIGOPHORA.

Most of the Flagellata previously recorded have been seen again. Remarks are appended on herpetomonads.

HERPETOMONAS IN VARIOUS HABITATS.

A young white rat was inoculated intraperitoneally on on February 20, 1922, with the intestinal contents of a house-fly, *Musca domestica*, infected with *Herpetomonas muscæ domesticæ*. The blood of the rat was examined daily at about 11 a.m. This daily examination is absolutely necessary, and the omission of it accounts for discrepancies in the accounts of authors who only examine the experimental host's blood casually, every few days, or—as one author recently expressed it—"at intervals of a few days." In the case of my experimental rat, a few young developing flagellate herpetomonads were seen in the ear blood on the ninth day after inoculation. These herpetomonads, however, were only seen on second examination of the blood on the ninth day, namely, in the afternoon, the blood appearing to be negative in the morning. Possibly there was a slight infection of the rat on the twenty-fifth day, but the infection was too slight to confirm from stained preparations. However, on the thirty-fifth day (March 29), there was a crop of flagellates in the blood of the rat in the morning when the blood was examined at 11 a.m. In the afternoon of the same day at 3 p.m. the blood was again examined, but no parasites were then seen. The infection had fulminated and then faded out, for the results of subsequent daily examinations were negative. The rat was in good health and not showing infection at the time of reading this paper, 144 days after inoculation. (The rat has remained well to the end of 1922, and has shown no further infection, having thus lived 315 days after inoculation, during which there was only one fulminating period followed by apparent recovery.)

It is of interest and importance to note the source of the *Herpetomonas muscæ domesticæ* used in this experiment, and to draw attention to the difficulty of finding the herpetomonad of the house-fly. Only four infections of *Musca domestica** have been observed by me in South Africa out of 286 house-flies examined during the last two years. Also, in England I had very great difficulty in finding this herpetomonad, as it did not occur in flies found in houses. In Johannesburg the infected flies have only been found in a horse's stable, and only during

* The house-flies were kindly identified for me by Mr G. A. H. Bedford, Entomologist at the Veterinary Research Laboratories, Onderstepoort.

the summer, namely, in November, 1921, and in January and February, 1922. The Musca preferred to feed around experimental puncture wounds on the neck of the stabled horse. Some of the Musca contained recently ingested blood, others contained blood in various stages of digestion in their alimentary tracts. The horse's blood was frequently examined, but was negative for Protozoa. While writing this paper, I was very interested in the remarks of R. W. Glaser* on his experiences with house-flies and *Herpetomonas muscæ domesticæ* in the neighbourhood of Princeton, U.S.A., and his experiences are much the same as mine, both as regards parasitised flies being found in summer (July and August in the United States) and as regards flies caught in dwelling houses not being parasitised with herpetomonads. Glaser's infected flies came from "cow barns and horse stables."

An interesting Herpetomonas, occurring in the posterior portion of the alimentary canal of the "clawed frog" or "clawed toad," *Xenopus lævis*, was seen by me on June 14, 1922, in fresh rectal scrapings. The flagellates were very few in number and were active. Only eight herpetomonads were found in the rectum, of which one was a dividing form with a body length of 17·5μ, while other non-dividing forms varied from 9μ to 17μ in length of body. The width of the body of the flagellates was 2μ to 2·5μ, which seems somewhat wide in comparison with the length of the body. The flagellum was single, of varying length, in some cases about one-third longer than the body, and was very flexible. Three rounded, leishmaniform parasites were seen, measuring about 4·5μ by 2μ. The rest of the gut of this Xenopus was examined, and only one more flagellate was seen near the junction of the small and large intestine. Six other Xenopus examined on the same day were found to be uninfected with herpetomonads. This Herpetomonas, found in the gut of Xenopus, may, for distinctive purposes, be provisionally named *Herpetomonas xenopi*, though it may ultimately prove to be a flagellate from an insect swallowed by the Amphibian host. Three more Xenopus have since been found infected with this Herpetomonas, but in each case the infection was very slight.

Herpetomonads have also been observed by me in hollow cabbage stalks, taken from a fodder room belonging to some animal houses in the district of Johannesburg. A few flagellates were first seen in cabbage stalks on March 10, 1920. They were found again on April 18, 1920, and three sketches were then made with the aid of a camera lucida, from which it was determined that two flagellate herpetomonads were 11μ and 18μ in body length respectively, and 1·5μ and 2μ in breadth. A rounded, spherical non-flagellate form was 2·5μ in diameter. Just a year after (April, 1921) more herpetomonads were found in a rotting cabbage stalk from the same fodder room. These flagellates varied in length of body from 6μ to 10μ and were 1·2μ to 1·8μ in breadth. A dividing flagellate was seen, and also a small non-flagellate, 2μ by 1·3μ. The flagellates, which were active, were living in the "messy"

* *Journal of Parasitology*, viii, pp. 99—108.

pulp of the cabbage stalk, in company with eel-worms and an Amœba. No insects were observed on the infected cabbages. Some rounded post-flagellate forms, unfortunately few in number, were rubbed into another uninfected cabbage stalk, but without cross-infection taking place. This herpetomonad, for purposes of identification and reference, may be named *Herpetomonas brassicæ*. It is of interest to note that herpetomonads have already been found in plants, for these flagellates were observed in the latex of members of the Euphorbiaceæ in Mauritius in 1909. More recently they have been found in other orders of plants. Sometimes insects, such as various plant bugs, are found crawling over the infected plants.

Elsewhere in this JOURNAL (see p. 344) I record the finding of a *Herpetomonas* in water cultures of South African soils. It measures 9μ to 21μ in body length and 1·5μ to 3μ in breadth, and, for purposes of reference, is named by me *H. terricolæ*. The soil herpetomonad possesses a kinetoplast (also known as a kinetonucleus and as a blepharoplast), so differing from the interesting allied organism, *Proleptomonas*, found by Woodcock* (1916) in sheep and goat dung in England.

Herpetomonads are well known to occur naturally in the alimentary tracts of insects and other invertebrates, also in the guts of a few vertebrates and in the blood of a few vertebrates. We have thus presented within this one genus a varied distribution of habitat, ranging from free-living to parasitic, and passing from life in moist soil to saprozoic existence in the alimentary tracts of animals, and finally to parasitic life in vertebrate blood and tissues, culminating in the pathogenic leishmaniases. Herpetomonads are also parasitic in some plant tissues.

That leishmaniases are insect-borne herpetomoniases is no new opinion, and much experimental work has been done which has pointed to this being a fact. Laveran and Franchini (1920) have shown that certain herpetomonads from the latex of *Euphorbia nereifolia* produce flagellate infections when inoculated into white mice.† In this connection, it is possible that plants infected with herpetomonads, in districts where kala-azar is endemic, may be concerned in the dissemination of this leishmaniasis. I have held this opinion for many years, and in 1915 I drew attention to this possibility and stated‡: "Nearly three years ago I was informed by a competent authority that a number of Euphorbia containing Herpetomonads grew outside a certain hospital situated in an area in which kala-azar was endemic, and in which kala-azar patients were being treated. The shrubs were infested by insects. It seems remarkable that no attempt was made to trace a possible connection between the plant herpetomonad and kala-azar; doubtless such a possibility

* *Phil. Trans.*, B 207, pp. 376, 382, 383.
† *Bull. Soc. Path. Exot.*, xiii, pp. 796—800.
‡ *Annals Trop. Med. and Parasitol*, ix, p. 341.

was considered too remote." With increasing knowledge, it is probable that someone will be able to experiment successfully and infect plants with the flagellates of human leishmaniases;* the converse experiment of infecting vertebrates with plant-inhabiting herpetomonads has already been done.

A Chilomastix has been found in small numbers in the intestine of adult *Xenopus lævis* in Johannesburg. Previously Chilomastix has been recorded from various tadpoles in Europe by Alexeieff in 1909, but I am not aware that it has been notified before from any adult Amphibian. The species in tadpoles has been named *Chilomastix caulleryi* by Alexeieff; perhaps the flagellate now recorded from adult Xenopus may prove to belong to that species.

A Chilomastix has also been observed by me in the small intestine and cæcum of guinea-pigs in Johannesburg. Unfortunately, the infection was sparse. Apparently the flagellate is *Chilomastix intestinalis* Kuczynski, 1914.

Two cases of giardiasis in rabbits were investigated, *Giardia cuniculi* Bensen occurring in the small intestines of the rodents. In neither case was diarrhœa obvious in life, but at post-mortem slight enteritis was observed in each cadaver.

Octomitus muris Grassi was found in the diarrhœic fæces of a mouse in June. Flagellates were passed per anum, and the dimensions of the bodies of two fully grown trophic forms drawn were 9μ by 3μ and 10μ by 4μ. The body of a perfectly formed, smaller flagellate, apparently full grown, measured 4μ long by 1·5μ broad. This may be a new variety, *Octomitus muris* var. *minor*.

Pleuromonas jaculans, a biflagellate usually occurring in stagnant water and infusions, as well as in moist soil, was seen in the rectal contents of a dead fowl and in the freshly-passed excrement of a water-tortoise, *Emys* sp. The Pleuromonas in these cases was a coprozoic flagellate.

Sporozoa.

From time to time a few coccidian oöcysts have been seen in the fæces of sheep and goats. Mention was made of those in sheep last year†

* Since this paper was written, my suggestion made in 1915 on information acquired in 1912 has obtained a wider significance and importance, and experimental evidence in support of it has been set forth. Thus, Franchini (*Bull. Soc. Path. Exot.*, xv, pp. 792—795, Nov., 1922) has succeeeded in producing an infection of the plant, *Euphorbia ipecacuanha*, by inoculating healthy specimens of the plant with cultures of the herpetomonad flagellate, *Leishmania donovani*, the causal agent of Indian kala-azar in man. The infection with the flagellates caused obvious disease in the plants experimented upon. The leishmania-infected plants became yellow, their leaves fell, their development was partly arrested, their shoots withered and the latex became pale and very fluid, while control plants grew well.

† This Journal, xviii, p. 166.

Free merozoites and gametocytes, belonging to *Eimeria arloingi*, have been seen in scrapings of the mucosa in and around minute ulcers in the small intestine of young goats. A few oöcysts of *E. arloingi*, averaging 29μ by 20μ, have been observed, in the cooler months of the year, in adult goats, which seem relatively unaffected thereby and serve as reservoirs of the parasite.

Sarcosporidia.—Further observations have been made during 1922 on the seasonal variation of Sarcosporidian spores in the heart muscle of sheep, recorded* previously by me. Spores of *Sarcocystis tenella* from the apex of the ventricle of adult sheep, killed in Johannesburg and Pretoria (Onderstepoort), were examined as often as possible, and the results obtained during the months of 1922 are now given in summary, the records for the latter part of 1922, up to date of publication, being added for completeness. Only a few observations were possible during January, otherwise a fairly representative series of examinations, as regards distribution through the various months of the year, were made. Altogether 97 sheep were examined, of which 51 were found to be infected with Sarcocystis. As before, it was found that during the cold or winter months of June, July and August in South Africa the Sarcosporidian spores were few. They were fewest during June, and few during July and the first half of August. Also, they were relatively few during the latter half of May. Between the middle of May and the middle of August, 27 uninfected specimens of ventricle were found, out of 46 uninfected specimens for the year. An increase in numbers of spores began to be apparent during the latter half of August, and the increase during September was obvious; that is, an increase occurred during the spring months in South Africa. Sarcosporidian spores were easily found and were relatively numerous during October, November, December, probably January, February, March and April, which are summer months in South Africa. A definite decrease began to be apparent early in May. On comparison it will be seen that the results herein recorded are much the same as those obtained by me in 1919-20 and in 1921.

Through the kindness of Dr. G. W. Robertson, of the Government Bacteriological Laboratory, Capetown, I have been informed of the occurrence in South Africa of that interesting and somewhat rare Haplosporidian, *Rhinosporidium kinealyi* Minchin and Fantham,* 1905. Dr. Robertson has very kindly given me his only preparation of the organism. All the essential stages described by the late Professor Minchin and myself are to be seen in the section. The material was obtained from a growth the size of a walnut on the posterior nares (back of the soft palate) of an Indian mattress maker of Capetown. The growth was removed by Dr. Elliott some ten years ago and sent to Dr.

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* This Journal, xviii, p. 167; xvii, pp. 132—133.

† *Quart. Journ. Microsc. Sci.*, xlix, pp. 521—532.

Robertson for examination. He later identified the organism and asked me to confirm his diagnosis. He now permits me to record the occurrence of Rhinosporidium in man in South Africa.

INFUSORIA.

In addition to the Ciliata previously recorded by me, all of which have been observed again, the following remarks on further observations may be of interest.

A very few specimens of *Didesmis quadrata* Fiorentini were found in the large colon of a horse which died of " staggers " on June 7, 1922, and was examined post-mortem at Onderstepoort.

On one occasion specimens of a Ciliate about 47μ to 56μ long and 25μ to 33μ broad were found in human urine sent for pathological examination. The organism was observed among casts after centrifuging. The urine was not quite fresh, perhaps six hours old, and so the Ciliate was probably a casual or contaminative organism in the urine. The Ciliate was, after some trouble, identified as *Chilodon uncinatus* Ehrenberg (also called *C. dentatus* de Fromentel), which has been reported as a " chance parasite " or " pseudo-parasite " from human diarrhœic stools.

In continuation of the examinations of the large intestines of pigs for *Balantidium coli*, mentioned in my former communications, the following additional results are now recorded. A further number of 32 pigs has been examined, of which 29 were from the Johannesburg area and 3 from Onderstepoort. Of these 32 pigs, 15 proved to be infected and 17 uninfected with Balantidia. In six of the infected pigs, Balantidia containing ingested red blood corpuscles were observed, while the remaining nine contained no erythrocytes in the Balantidia, though ingested " mealie " starch grains were sometimes present in the ciliates. In the six cases in which Balantidia containing red blood corpuscles were present, the sites of infection were as follows: In three pigs the cæcum and rectum both were infected, in one case cæcum, colon and rectum contained the parasites, while in two cases the cæcum only harboured Balantidia. Of the nine cases in which Balantidia without erythrocytes were observed, the cæcum and rectum were both infected in three cases, the cæcum, colon and rectum in one case, the cæcum only in two cases and the rectum only in three cases. The cæcum thus seems the site most favourable to the existence of *Balantidium coli*, as judged by the frequency of its infection. In two cases minute ulcers were present in parasitised cæca. However, most of the pigs were apparently healthy.

The new species, *Balantidium suis*, found by McDonald* (1922) in pigs in California has not yet been observed by me in pigs in South Africa.

Regarding the Ciliata found in the rumen and reticulum of sheep and cattle, it is interesting to record that species of

* University of California Publications in Zoology, xx, p. 250.

Entodinium and of Diplodinium may be found on wet grass and in aqueous washings of fresh grass and even of dried grass (fodder) from sheep runs and pasturage. The firm cuticle of the Ciliata sufficiently preserves the organism during such exposure. Sheep and cattle are infected with the ciliates mentioned while eating grass or hay.

Spirochætæ.

Spirochætes, similar to those recorded in my last communication as occurring in the reticulum of sheep, were seen in the rumen, as well as in the reticulum, of a sheep in Johannesburg in February.

A few Spirochætes of the *S. balbianii* type were again seen in the digestive tract, as well as in the digestive gland, of *Physopsis africana*. The Gastropod hosts, like those of last year, were obtained in the neighbourhood of Durban.

A few specimens of a Spirochæte of the *S. balbianii* type have also been observed in rectal scrapings of a *Xenopus lævis*. The organisms measured about 50μ to 52μ long. *S. balbianii*, or allied types of this crested Spirochæte, have now been recorded from the alimentary tracts of Lamellibranchs, Gastropods and Amphibia. It seems that *S. balbianii* was at first a water-inhabiting Spirochæte that has been swallowed by various animals, and has habituated itself to life in digestive tracts of various hosts.

Acknowledgments.

I have much pleasure in thanking the Director and Officers of the Veterinary Research Laboratory at Onderstepoort and the Officers of the Johannesburg Abattoirs for material. Also, I wish to thank the Research Grant Board very cordially for a grant towards the expenses incurred in these investigations.

SOME PROTOZOA FOUND IN CERTAIN SOUTH AFRICAN SOILS.—II.

BY

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Read July 13, 1922.

CONTENTS.

INTRODUCTION.

The present paper contains an account of some further results obtained by us in our investigations of the Protozoa of South African soils, and is a continuation of the work on which a report was made to this Association last year. (See this JOURNAL, vol. XVIII, pp. 373-393.)

Further samples of soils from places in the Cape Province and the Transvaal have been examined, and a commencement has been made in the examination of soils from places in the Orange Free State, which was not possible before, while a few samples from the Lourenço Marques district were obtained. Further examinations of waterlogged soils have also been made. Observations on environmental effects have been continued.

In order really to comprehend what organisms are present in soils and their inter-relationships, soils must be examined in their natural condition, without the addition of artificial culture media. As mentioned in our previous communication, it is possible that the biological activities of both Protozoa and bacteria are altered in artificial media, and hence the method of water culture has been continued by us, this approximating most nearly to the condition obtaining in nature. Record also is needed of all the Protozoa present in any one soil, and the protozoal fauna must be considered as a complete whole. Organisms that develop relatively slowly may, in the end, prove to be more important than those that develop more quickly, and numbers are not always a mark of importance.

Material and Methods.

In connection with material, soils have been collected as before, care being taken to make each sample of soil representative of the area concerned. Particulars of each sample are given under the accounts of the Protozoa found in the water cultures of each soil.

The method of water culture has been employed for the reason already given, and cultures have usually been made in the proportion of 5 grams of soil to 10 c.c. of boiled tap water. The usual bacteriological precautions have been taken to avoid contamination.

For the purpose of counting the actual numbers of organisms, the method used was as follows:—Measured quantities of culture fluid, including portions from the various levels or depths of the culture have been examined in the graduated chamber of a hæmocytometer. The slow moving organisms, such as thecamœbæ, amœbæ and *Euglena oxyuris*, are then easily counted in life. For rapidly moving organisms, such as some Flagellates and Ciliates (when moving too quickly to be counted alive), a measured volume of culture fluid has been mixed with an equal quantity of hot Schaudinn fluid or Carnoy fixative, and the organisms are thus killed and fixed. A little methyl green has sometimes been added and found useful. The number of organisms has then been counted either in the hæmocytometer or in a series of cover-slip wet preparations. Naturally, thecamœbæ and amœbæ can be estimated by this method, though it has often been found easier to count them in the living condition.

Results of Examinations of Various Ordinary (Non-Waterlogged) Soils.

The soils herein discussed may be grouped according to the geographical area whence they were obtained.

Cape Province Soils.

An intensive study of soil from three areas of the Rosebank Experimental Station, near Cape Town, was made, and Eastern Province soils were represented by samples from the Grootfon-

tein School of Agriculture, Middelburg, and from the George district.

Rosebank Experiment Station.—Three areas were examined. The first sample consisted of twelve one-inch layers of soil, taken very carefully, without either admixture or wastage, and forming a compact block twelve inches deep. A thirteenth sample was a composite one of all the layers, one to twelve inches inclusive. The samples were secured on May 15, 1922, rain having fallen the previous day. (This was at the commencement of the Cape Peninsula rainy season). They were Liesbeek alluvial soil, taken from cultivated land within three yards from the river, and the soil had not been disturbed. These samples are referred to as Liesbeek 1, 2, 3......13.

Soil from the second area, termed Liesbeek 14, was a composite sample from a large open storm water drain under the fig trees and was detritus from the streets and gardens of Rose bank.

Soil from the third area, termed Liesbeek 15, was from a sod in a grazing camp at Rosebank, that had not been disturbed for years.

Cultures were made in each case in the proportion of 5 grams of soil to 10 c.c. of boiled sterile tap water.

In no case were trophic Protozoa detected on direct examination. The first motile Protozoa were found in the culture fluid 25 hours after the culture was made. Each specimen of soil gave a feebly acid reaction to litmus. This series of samples also yielded interesting information as to the occurrence of Protozoa at different depths in the soil. (See p. 360.)

The Protozoa found in each sample may now be set forth, beginning with the layer from the surface to one inch deep, termed Liesbeek 1.

Liesbeek 1.—The Protozoa found in water culture were:—

Rhizopoda.—*Amœba proteus*, *A. limax*, *A. guttula*, *Euglypha* sp.

Mastigophora.—*Peranema trichophorum*, *Mastigamœba* sp., *Oikomonas termo*, *Bodo* (*Prowazekia*) *parva*.

Infusoria.—*Prorodon ovum*, *Lacrymaria olor*, *Cyclidium glaucoma*, *Vorticella campanula*.

Liesbeek 2.—The Protozoa found in water culture were:—

Rhizopoda.—*Amœba limax*, *A. guttula*, *Euglypha* sp.

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo* (*P.*) *parva*, *Euglena oxyuris*, *Pleuromonas jaculans*.

Infusoria.—*Holophrya ovum*, *Lacrymaria olor*, *Cyclidium glaucoma*, *Paramœcium aurelia*, *P. putrinum*, *Vorticella campanula*.

Liesbeek 3.—The following Protozoa were found in water culture:—

Rhizopoda.—*Amœba proteus*, *A. limax*, *Euglypha* sp.

Mastigophora.—*Oikomonas termo, Bodo (P.) parva, Pleuromonas jaculans.*

Infusoria.—*Stylonychia mytilus, Euplotes harpa, Uroleptus piscis.*

Liesbeek 4.—The Protozoa found in water culture were:—

Rhizopoda.—*Amœba proteus, A. limax, A. guttula, Euglypha alveolata, Euglypha* sp.

Heliozoa.—*Actinophrys sol.*

Mastigophora.—*Peranema trichophorum, Oikomonas termo, Pleuromonas jaculans, Euglena viridis.*

Infusoria.—*Lacrymaria olor, Stylonychia mytilus.*

Liesbeek 5.—Water cultures yielded the following Protozoa:—

Rhizopoda.—*Amœba limax, A. guttula, Euglypha* sp.

Heliozoa.—*Actinophrys sol.*

Mastigophora.—*Oikomonas termo, Bodo (P.) parva, Euglena oxyuris, Pleuromonas jaculans.*

Infusoria.—*Holophrya ovum, Colpoda cucullus, Cyclidium glaucoma.*

Liesbeek 6.—The Protozoa observed in water culture were:—

Rhizopoda.—*Amœba limax, Difflugia globulosa, Euglypha* sp.

Mastigophora.—*Peranema trichophorum, Oikomonas termo, Bodo (P.) parva, Euglena viridis, E. oxyuris, Pleuromonas jaculans.*

Infusoria.—*Holophrya ovum, Lacrymaria olor, Colpoda cucullus, Colpidium striatum, Cyclidium glaucoma.*

Liesbeek 7.—The Protozoa found in water culture were:—

Rhizopoda.—*Euglypha* sp.

Mastigophora.—*Oikomonas termo, Bodo (P.) parva, Euglena viridis, E. oxyuris, Pleuromonas jaculans.*

Infusoria.—*Paramœcium aurelia, P. putrinum, Vorticella campanula.*

All these Protozoa (in Liesbeek 7) were present in extremely small numbers and were irregular in the time of their appearance, often disappearing entirely over periods of several days.

Liesbeek 8.—Water cultures of the soil yielded the following Protozoa:—

Rhizopoda.—*Amœba proteus, A. limax, A. guttula, Difflugia globulosa, Euglypha alveolata, Euglypha* sp.

Mastigophora.—*Oikomonas termo, Bodo (P.) parva, Euglena viridis, E. oxyuris, Pleuromonas jaculans.*

Infusoria.—*Holophrya ovum, Lacrymaria olor, Cyclidium glaucoma, Vorticella campanula.*

Amœba limax, in this culture, were occasionally seen to be ingesting bacteria.

Liesbeek 9.—The following Protozoa were observed in water culture of this soil:—

Rhizopoda.—*Amœba limax, A. guttula, Euglypha* sp.

Heliozoa.—*Actinophrys sol.*

Mastigophora.—*Peranema trichophorum, Oikomonas termo, Bodo (P.) parva, Pleuromonas jaculans.*

Infusoria.—*Holophrya ovum, Colpoda cucullus, Colpidium striatum, Cyclidium glaucoma.*

Liesbeek 10.—The water cultures of this soil yielded the following Protozoa:—

Rhizopoda.—*Amœba limax, A. guttula, Euglypha* sp.

Mastigophora.—*Oikomonas termo, Bodo (P.) parva, Euglena viridis, E. oxyuris, Herpetomonas* sp.,* *Pleuromonas jaculans.*

Infusoria.—*Holophrya ovum, Cyclidium glaucoma, Colpoda cucullus, Colpidium striatum, Uroleptus piscis.*

Liesbeek 11.—The following Protozoa were detected in water culture:—

Rhizopoda.—*Amœba proteus, A. limax, A. guttula, Euglypha* sp.

Mastigophora.—*Oikomonas termo, Euglena oxyuris, Pleuromonas jaculans.*

Infusoria.—*Lacrymaria olor, Colpoda cucullus, Paramœcium aurelia, P. putrinum, Stylonychia mytilus, Uroleptus piscis, Vorticella campanula.*

Liesbeek 12.—The water culture of this soil yielded the following Protozoa:—

Rhizopoda.—*Euglypha* sp.

Mastigophora.—*Oikomonas termo, Bodo (P.) parva, Pleuromonas jaculans.*

Infusoria.—*Lacrymaria olor, Stylonychia mytilus, Uroleptus piscis, Vorticella campanula.*

Liesbeek 13.—This sample was a composite one of all the layers from one to twelve inches deep. In water culture it yielded the following Protozoa:—

Rhizopoda.—*Amœba limax, Euglypha* sp.

Heliozoa.—*Actinophrys sol.*

Mastigophora.—*Peranema trichophorum, Oikomonas termo, Bodo (P.) parva, Pleuromonas jaculans.*

Iufusoria.—*Holophrya ovum, Lacrymaria olor, Colpoda cucullus, Colpidium striatum, Cyclidium glaucoma, Uroleptus piscis, Vorticella campanula.*

It will be seen that all the Protozoa found in the culture of this composite soil are present in one or other of the constituent layers, and that very few of the kinds of Protozoa found in the individual layers are unrepresented in the composite layer.

Liesbeek 14.—This was a composite sample taken from a large storm water drain under fig trees at the Rosebank Experimental Station on May 15, 1922. It consisted of detritus from the streets and gardens of Rosebank, deposited in the bed of the drain under the influence of a backwater from the Liesbeek when in flood. Its reaction was feebly acid to litmus.

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* This soil *Herpetomonas* measures 9μ to 21μ in body length and 1.5μ to 3μ in breadth. I propose for it the name, *Herpetomonas terricolae*, for distinctive purposes. However, it is sometimes referred to as *Herpetomonas* sp. in the text.

On water culture the following Protozoa were obtained:—

Rhizopoda.—*Amœba proteus, A. limax, A. radiosa, A. verrucosa, A. guttula, Difflugia pyriformis, D. globulosa, Euglypha* sp.

Heliozoa.—*Actinophrys sol, Acanthocystis aculeata.*

Mastigophora.—*Peranema trichophorum, Mastigamœba* sp., *Oikomonas termo, Bodo (P.) parva, Euglena oxyuris, Herpetomonas terricolæ.*

Infusoria.—*Lacrymaria olor, Paramœcium putrinum, Cyclidium glaucoma, Spirostomum ambiguum, Stylonychia mytilus, Uroleptus piscis.*

This sample of soil yielded no less than 22 species of Protozoa, and they were present in relatively large numbers.

Liesbeek 15.—This specimen consisted of a block of soil cut from a sod in a grazing camp. The latter had not been touched for years.

On culture, extremely few organisms were obtained, and the periods of negative results were much more numerous than those on which Protozoa were observed.

The Protozoa found were:—

Rhizopoda.—*Amœba limax, Euglypha* sp.

Mastigophora.—*Oikomonas termo, Bodo (P.) parva.*

Infusoria.—*Holophrya ovum, Colpoda cucullus, Vorticella campanula.*

It seems possible that years of trampling by cattle had so compressed the surface of the soil as to make it an unfavourable terrain for Protozoa.

Grootfontein, School of Agriculture, Middelburg, C.P.—Two samples of Red Karroo soils were obtained on April 11, 1922, namely, virgin Red Karroo and cultivated Red Karroo. They were taken at a depth of nine inches below the surface from the sites at which previous samples for examination had been obtained. (See this Journal, vol. XVIII, pp. 379, 380.) The reaction to litmus was feebly alkaline in each case.

Water cultures yielded the following Protozoa:—

(i) Virgin Red Karroo.

Rhizopoda.—*Euglypha* sp.

Mastigophora.—*Peranema trichophorum, Oikomonas termo, Pleuromonas jaculans.*

Infusoria.—*Lacrymaria olor, Cyclidium glaucoma.*

Rhizopoda.—*Amœba limax, Euglypha* sp.

Mastigophora.—*Peranema trichophorum, Oikomonas termo, Bodo (P.) parva, Cercomonas crassicauda, Pleuro-*

(ii) Cultivated Red Karroo.

monas jaculans.

Infusoria.—*Coleps hirtus, Cyclidium glaucoma.*

As in the previous examinations, there is again a marked difference between the protozoal fauna of virgin and cultivated Karroo soils, the latter being richer in genera and also having a greater total number of Protozoa present.

George District.—Three samples of soil were obtained from the district of George on September 19. Each soil gave an acid reaction to litmus.

(i) Soil from farm Gwaayang, about six miles south-west of George. This was a common type of soil from the so-called intermediate belt, and is used for growing potatoes, wheat, sweet potatoes, etc. It overlies granite, but does not appear to have been derived from it. The rainfall of the district is about 30 inches per annum. The altitude is about 600 feet above sea level. The soil as received was light brown, sandy, finely divided, and contained a few plant roots. It was a mixed sample from the surface to five inches deep (plough depth). No Protozoa were found on direct examination.

In water culture the following organisms were observed:—

Rhizopoda.—*Amœba proteus*, *A. limax*, *A. verrucosa*, *A. guttula*, *Euglypha* sp.

Heliozoa.—*Actinophrys sol*.

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo* (*P.*) *parva*, *Cercomonas crassicauda*, *Entosiphon sulcatum*, *Pleuromonas jaculans*.

Infusoria.—*Cyclidium glaucoma*.

Ciliates were very rare in this culture.

(ii) Sample of soil from the lower slopes of the Jonkersberg. The Union Forestry Department is planting *Pinus insignis* extensively on these slopes. The pines here have made hardly any growth. The altitude is about 1,200 feet above sea level. There is no dry season, the rainfall is about 40 inches per annum, and heavy rain had fallen a few days before the sample was taken. The specimen was a dark, crumbly, loamy soil, and was damp when received. It was a mixed sample from the surface to eight inches deep. No Protozoa were observed on direct examination.

The following Protozoa, however, were found in water cultures:—

Rhizopoda.—*Amœba proteus*, *A. guttula*, *Difflugia globulosa*, *Euglypha alveolata*, *Euglypha* sp.

Heliozoa.—*Actinophrys sol*.

Mastigophora.—*Oikomonas termo*, *Bodo* (*P.*) *parva*, *Euglena oxyuris*, *Entosiphon sulcatum*.

Infusoria.—*Amphileptus cygnus*.

The Protozoa were present in small numbers only.

(iii) Sample of soil from the lower slopes of the Jonkersberg, where the Union Forestry Department is planting *Pinus insignis* extensively, but where the growth of the pines is good. The rainfall and general conditions are like those of the previous soil. The soil itself was a dark, loamy, crumbly soil, slightly damp, but not so damp as specimen (ii) when received. The sample was a mixed one, from the surface to eight inches deep. No motile Protozoa were detected on direct examination, but thecæ of

Euglypha and cysts of a ciliate were seen. On water culture the following Protozoa were obtained:—

Rhizopoda.—*Amœba proteus*, *A. guttula*, *Difflugia globulosa*, *Euglypha alveolata*, *Euglypha* sp.

Heliozoa.—*Actinophrys sol.*

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo (P.) parva*, *Cercomonas crassicauda*, *Entosiphon sulcatum*, *Euglena oxyuris*.

Infusoria.—*Lacrymaria olor*, *Colpoda cucullus*, *Cyclidium glaucoma*, *Paramœcium aurelia*, *Stylonychia mytilus*, *Vorticella companula*.

There is a marked difference, particularly seen in the Infusoria, between the fauna of the two cultures of soil under forestry cultivation. The part in which the growth of *Pinus insignis* was good showed larger numbers of genera of Protozoa and also a larger total number of organisms than the culture of soil on which the pines had made less progress.

Transvaal Soils.

Observations were made on samples of soil obtained from the same districts as those reported on previously by us, in order to try to determine any seasonal variation in the protozoal fauna of the soil in those neighbourhoods. Unfortunately, the data available at present hardly seem sufficient to justify very definite conclusions. The records of the observations are as follow:—

Johannesburg, Houghton Estate.—The specimen of soil was collected on March 23, 1922, at the end of the Transvaal rainy season. It was garden soil under cultivation as a flower and vegetable garden, and the sample was a mixed one of the top nine inches of soil. Its reaction to litmus was acid.

Water cultures yielded the following Protozoa:—

Rhizopoda.—*Amœba proteus*, *Difflugia pyriformis*, *Arcella vulgaris*.

Mastigophora.—*Oikomonas termo*.

Infusoria.—*Euplotes harpa*.

Potchefstroom.—Soil was collected from a cultivated fallow on the farm of the Agricultural College, Potchefstroom, on August 1. It was a light brown sandy loam, and was a mixed sample of all layers up to and including twelve inches in depth. Its reaction was feebly acid to litmus. No Protozoa were observed on direct examination.

In water culture the following Protozoa were obtained, the numbers always being very small and with long intervals between the successive appearances:—

Rhizopoda.—*Amœba proteus*, *A. limax*, *A. guttula*, *Difflugia globulosa*, *Euglypha* sp.

Heliozoa.—*Actinophrys sol.*

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo (P.) parva*, *Entosiphon sulcatum*, *Pleuromonas jaculans*.

Infusoria.—*Halteria grandinella*, *Uroleptus piscis*.

No motile Protozoon was observed until 72 hours after the culture was made, when *Bodo* (*Prowazekia*) *parva* first appeared. On the fifth day of culture a very few bacteria were observed, but they disappeared the same day and have not been seen since.

It may be remarked that the culture under discussion was maintained longer than those of Potchefstroom soils recorded in our paper of last year, in which the depth of each of the mixed samples should have been stated to be to twelve inches and not to six inches.

Onderstepoort.—A sample of soil was obtained on March 22, 1922, from a natural plantation of Syringas near the post mortem hall at the Veterinary Research Laboratory, in fine sunshiny weather. There had been no rain for some time. The sample was taken at a depth of four inches from the surface, with slight admixture of the layers from above. The soil was a deep chocolate, clayey loam with some humus. It was feebly acid in its reaction to litmus.

No Protozoa were detected on direct examination, but the following Protozoa were obtained in water culture:—

Rhizopoda.—*Amœba proteus*, *A. limax*, *A. guttula*, *A. radiosa*, *Difflugia globulosa*, *Euglypha* sp., *Arcella vulgaris*.

Heliozoa.—*Actinophyrs sol*.

Mastigophora.—*Peranema trichophorum*, *Bodo* (*P.*) *parva*, *Oikomonas termo*, *Cercomonas crassicauda*, *Pleuromonas jaculans*.

Infusoria.—*Holophrya ovum*, *Colpoda cucullus*, *Cyclidium glaucoma*, *Stylonychia mytilus*, *Vorticella campanula*.

In this culture a few Nematode larvæ were observed. Vibrios and other bacteria were found at certain times, and *Bodo* (*P.*) *parva* have been seen ingesting vibrios. Cysts of a species of Euglena were found in the early days of culture, but subsequent development was not observed. The cultures were kept at room temperature and a very cold period set in, which adversely affected them.

Orange Free State Soils.

Samples of soil were obtained from Winburg, Bloemfontein and Glen in the Orange Free State. The specimens included virgin, cultivated and uncultivated soils.

Winburg.—Two specimens of soil were obtained. The samples were taken on April 6, 1922, each being a sample of soil from a depth of six inches from the surface, without admixture with other layers. One specimen was from uncultivated, practically virgin land; the other was good mealie land. Both soils reacted feebly acid to litmus.

(i) Uncultivated soil. This was a dark chocolate loam, consisting of fairly finely divided particles. A surface film of soil, wetted with boiled tap water, showed cysts of *Difflugia*

globulosa and *Euglypha* sp. No motile organisms were detected. Water cultures yielded the following Protozoa:—

Rhizopoda.—*Difflugia globulosa, Euglypha* sp.
Heliozoa.—*Acanthocystis aculeata.*
Mastigophora.—*Mastigamœba* sp., *Oikomonas termo, Bodo (Prowazekia) parva, Euglena spirogyra, Cercomonas crassicauda, Pleuromonas jaculans.*
Infusoria.—*Holophrya ovum, Colpidium striatum, Cyclidium glaucoma, Spirostomum ambiguum, Stylonychia mytilus, Vorticella campanula.*

With the exception of *Pleuromonas jaculans*, none of the Protozoa was abundant.

(ii) Cultivated soil. This consisted of a dark chocolate loam, very finely divided. A surface film of soil wetted with boiled tap water was examined prior to culture. Cysts of Amœbæ, *Difflugia globulosa* and *Euglypha* sp. were observed. No motile organisms were present. On water culture the following Protozoa were obtained:—

Rhizopoda.—*Amœba limax, Difflugia globulosa, Euglypha* sp.
Mastigophora. — *Peranema trichophorum, Oikomonas termo, Bodo (P.) parva, Pleuromonas jaculans.*
Infusoria.—*Lacrymaria olor, Colpoda cucullus, Colpidium colpoda, Cyclidium glaucoma.*

The result of these two cultures was somewhat surprising, the uncultivated soil yielding more genera of Protozoa than the cultivated soil. Several organisms were common to both cultures. So far as total numbers of organisms were concerned, the culture of cultivated soil yielded a greater total than that of the uncultivated soil. The Protozoa were also more actively motile in the culture of the cultivated soil.

Glen.—Six samples of soil were obtained from different parts of the lands of the School of Agriculture, Glen, on September 20 during bright sunshine. They were mixed samples of the first six inches depth of soil.

Glen (i). This sample was collected from the river lands and consisted of virgin soil on the north bank of the Modder River, one hundred yards to the south-east of the distributor, in the mimosa belt. This soil gave an acid reaction to litmus. No Protozoa were detected on direct examination. Water cultures yielded the following Protozoa:—

Rhizopoda.—*Amœba guttula, Euglypha* sp.
Mastigophora.—*Oikomonas termo, Bodo (P.) parva, Pleuromonas jaculans.*
Infusoria.—*Holophrya ovum, Lacrymaria olor, Amphileptus cygnus, Colpoda cucullus, Cyclidium glaucoma, Paramœcium aurelia.*

Glen (ii). This sample was from the river lands, from a cultivated patch of Sudan grass, on the west of the road to the station and north of the main furrow. The area is one of mixed bush and grass veld, used for irrigation and grazing. The

reaction of the soil to litmus was practically neutral. Water cultures in the proportion of 5 grams of soil to 10 c.c. of boiled sterile water were made. No organisms were detected on direct examinations. The water cultures yielded:—

Rhizopoda.—*Euglypha* sp.

Mastigophora. — *Peranema trichophorum*, *Oikomonas termo*, *Bodo* (*Prowazekia*) *parva*, *Entosiphon sulcatum*, *Pleuromonas jaculans*.

Infusoria.—*Lacrymaria olor*, *Cyclidium glaucoma*.

Glen (iii). This was a sample of soil from virgin grass veld, giving a very feebly acid reaction to litmus. No organisms were observed on direct examination, and in water cultures very few Protozoa appeared. These were:—

Rhizopoda.—*Amœba verrucosa*, *Euglypha* sp.

Mastigophora. — *Peranema trichophorum*, *Oikomonas termo*, *Bodo* (*P.*) *parva*.

Infusoria.—*Colpoda cucullus*, *Cyclidium glaucoma*.

Glen (iv). This sample was collected from a cultivated experimental plot of grass veld used for depth ploughing experiments. The soil was a sandy loam overlying ironstone, and was neutral to litmus. No organisms were detected on direct examination. Water cultures were made and the following organisms were obtained:—

Rhizopoda.—*Amœba proteus*, *A. guttula*, *Euglypha alveolata*, *Euglypha* sp.

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo* (*P.*) *parva*, *Pleuromonas jaculans*.

Infusoria.—*Paramœcium aurelia*, *Cyclidium glaucoma*, *Euplotes harpa*.

Glen (v). This sample was collected during bright sunshine from an uncultivated, infertile patch of soil, 200 yards from the Zoetewoud boundary line. It was a crumbly light red loam, apparently brak, and was acid to litmus. No Protozoa were detected on direct examination. In water cultures the following Protozoa were seen:—

Rhizopoda.—*Amœba limax*, *A. guttula*, *Euglypha* sp.

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo* (*P.*) *parva*, *Herpetomonas terricolæ*.

Infusoria.—*Cyclidium glaucoma*, *Halteria grandinella*.

Glen (vi). This sample of soil was obtained from an infertile patch of ground that had been cultivated under mealies for about two seasons. The sample was a mixed one of the top six inches of soil. Its reaction to litmus was feebly acid. No Protozoa were seen on direct examination. The following Protozoa were obtained in water cultures in very small numbers:—

Rhizopoda.—*Amœba guttula*, *Euglypha* sp.

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo* (*P.*) *parva*, *Pleuromonas jaculans*, *Herpetomonas terricolæ*.

Infusoria.—*Lionotus fasciola*, *Cyclidium glaucoma*.

Negative periods of several days' duration occurred, when no Protozoa were detected in the culture.

The distribution of the different organisms in the series of Glen soils may be summarised in Table I.

TABLE I.

GLEN SOILS.

Organism.	River Lands Virgin.	River Lands cultivated.	Grass Veld, Virgin.	Grass Veld cultivated experimental.	Infertile patch uncultivated.	Infertile patch cultivated.
Amoeba proteus ..				1		
Amoeba limax					1	
Amoeba verrucosa ..			1			
Amoeba guttula ..	1			1	1	1
Euglypha alveolata ..				1		
Euglypha sp.	1	1	1	1	1	1
Peranema trichophorum		1	1	1	1	1
Oikomonas termo ..	1	1	1	1	1	1
Bodo (P.) parva ..	1	1	1	1	1	1
Entosiphon sulcatum ..		1				
Herpetomonas terricolae					1	1
Pleuromonas jaculans	1	1		1		1
Holophrya ovum ..	1					
Lacrymaria olor ..	1	1				
Amphileptus cygnus ..	1					
Lionotus fasciola ..						1
Colpoda cucullus ..	1		1			
Cyclidium glaucoma ..	1	1	1	1	1	1
Paramoecium aurelia ..	1			1		
Halteria grandinella ..					1	
Euplotes harpa ..				1		
TOTAL	11	8	7	11	9	9

From a consideration of Table I, the following facts are established:—

Certain Protozoa are common to all the soils examined from Glen. These are the Thecamœba, *Euglypha* sp., and two Flagellates, namely, *Oikomonas termo* and *Bodo* (*Prowazekia*) *parva*, as well as the Ciliate, *Cyclidium glaucoma*.

Different species of Amœbæ occur in different types of soils.

The Herpetomonas (*H. terricolæ*) was observed only in cultures of infertile patches.

Comparing fertile with infertile areas at Glen, it was found that the total number of individual Protozoa was greater in fertile than in infertile soils, as shown by water cultures.

Bloemfontein.—Two samples of soil were obtained from Bloemfontein on September 19, during bright sunshine. No rain had fallen for some time. Each sample was a mixed one of the top six inches of soil.

(i) Uncultivated grass veld. This specimen was taken from uncultivated area in the grounds of Grey University College,

Bloemfontein. It was a red sandy loam, with a very feebly acid reaction to litmus. A culture was made in the proportion of 5 grams of soil to 10 c.c. of boiled sterile water. No Protozoa were observed on direct examination.

Water cultures yielded the following Protozoa:—

Rhizopoda.—*Amœba proteus*, *A. limax*, *A. guttula*, *Difflugia globulosa*, *Euglypha* sp.

Heliozoa.—*Actinophrys sol*.

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo (P.) parva*, *Entosiphon sulcatum*.

Infusoria.—*Cyclidium glaucoma*, *Paramœcium aurelia*.

The number of kinds of Protozoa in this soil was relatively large, but the total number of individual Protozoa was small. The culture was slow in developing, and during the first 24 days, on three days only were Protozoa observed. *Bodo (Prowazekia) parva* was seen on two days and *Oikomonas termo* on one day. No Protozoa were found in the samples of the culture examined on 38 days out of 51 days, and two continuous periods of seven days and one of eight days were entirely negative.

(ii) Cultivated soil from the Botanic Gardens, Grey University College. This sample was collected in bright sunshine. No rain had fallen for some time, but the garden had been watered. The soil was an ironstone gravel, and its reaction to litmus was very feebly acid.

A culture in proportion of 5 grams of soil in 10 c.c. boiled sterile water yielded the following Protozoa:—

Rhizopoda.—*Amœba proteus*, *A. limax*, *Euglypha* sp.

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo (P.) parva*, *Euglena oxyuris*, *Pleuromonas jaculans*.

Infusoria.—*Amphileptus cygnus*.

As in the case of the uncultivated grass veld from Bloemfontein, the total number of organisms was small, and there were long negative periods in the culture. On 43 days out of 51 no Protozoa were detected.

Portuguese East African Soils.

For purposes of comparison, three samples of soil were obtained from the district of Lourenço Marques, Portuguese East Africa.

Observatory Garden, Lourenço Marques.—The sample was collected on July 14, during fine weather, from a bed of beans that had been recently watered. Goat dung was scattered over the bed as fertiliser. A mixed sample of surface to soil six inches deep was taken. It was sandy, bright reddish brown soil, with a very feebly acid reaction to litmus.

A culture was made in the proportion of 5 grams of soil to 10 c.c. of boiled sterile water. No motile Protozoa were observed when the culture was examined as soon as made, but the culture

proved rich in Protozoa subsequently. The following motile Protozoa were observed:—

Rhizopoda.—*Amœba proteus*, *A. limax*, *A. verrucosa*, *A. guttula*, *A. radiosa*, *Difflugia globulosa*, *Euglypha alveolata*, *Euglypha* sp.

Heliozoa.—*Actinophrys sol.*

Mastigophora.—*Peranema trichophorum*, *Oikomonas termo*, *Bodo (P.) parva*, *Euglena viridis*, *E. oxyuris*, *Entosiphon sulcatum*, a *Herpetomonas* on one occasion.

Infusoria.—*Holophrya ovum*, *Lacrymaria olor*, *Amphileptus cygnus*, *Coleps hirtus*, *Colpoda cucullus*, *Cyclidium glaucoma*, *Spirostomum ambiguum*, *Stylonychia mytilus*, *Euplotes harpa*, *Uroleptus piscis*.

In addition to the foregoing Protozoa, many of which are normal occupants of soil and fresh water, certain encysted Protozoa, some pathogenic, some harmless to man, were also found. These included tetranucleate cysts of *Entamœba histolytica*, cysts of *Entamœba coli* containing eight nuclei, and typical oval cysts of *Giardia* (*Lamblia*) *intestinalis*. As the methods for disposal of excrement by natives and others are somewhat primitive, and as night soil is used as fertiliser, this result is not altogether unexpected. Cultures of this soil also revealed ova of Trematodes and Nematodes and some free-living small Nematodes.

Botanic Gardens, Lourenço Marques.—This specimen was collected during fine weather on July 14, from the side of a freshly cut trench that was slightly shaded by bamboos. It was a dark brown, sandy soil, containing a slight admixture of bamboo roots, and was a mixed sample of soil from the surface to six inches deep. Its reaction to litmus was feebly acid.

A culture in the proportion of 5 grams of soil to 10 c.c. of boiled sterile water was made. It showed no motile Protozoa when examined immediately after being made. The following organisms were found subsequently, but never in large numbers:

Rhizopoda.—*Amœba proteus*, *Euglypha* sp.

Mastigophora.—*Oikomonas termo*, *Bodo (P.) parva*.

Infusoria.—*Lacrymaria olor*, *Colpoda cucullus*, *Aspidisca costata*, *Stylonychia mytilus*, *Uroleptus piscis*, *Euplotes harpa*.

A few bacteria were occasionally observed in this culture.

Marracuene.—This sample was collected on July 16. It was a mixed sample of soil from the surface to three inches deep, light brown, sandy, and was obtained from an uncultivated agave plantation. Its reaction to litmus was very feebly acid. A culture in the proportion of 5 grams of soil to 10 c.c. of boiled sterile water yielded very few Protozoa. These were:—

Rhizopoda.—*Amœba limax*, *Euglypha* sp.

Heliozoa.—*Actinophrys sol.*

Mastigophora.—*Oikomonas termo*, *Bodo (P.) parva*.

An eight-nucleate cyst resembling that of *Entamœba coli* was also observed. Ciliates were not found in this soil culture,

though relatively large numbers of genera of ciliates occurred in the other samples of soil from Portuguese East Africa.

The three soils showed considerable differences of fauna among themselves, but practically all the genera and species of Protozoa found therein occur also in soils that we have examined from the Union of South Africa.

Results of Examinations of Waterlogged Soils.

Samples of waterlogged soils were obtained from five localities in the neighbourhood of Johannesburg, and were examined for the presence of trophic Protozoa. The method of examination was the same as previously detailed on page 385 of our paper of last year.

Bedford Court, near Johannesburg.—Two samples of soil were obtained on April 24 during the dry season.

(i) Waterlogged soil from the edge of the open-air swimming bath was taken at the level of the water. The soil was black, mixed with some sand and vegetable debris, and gave an acid reaction to litmus.

One-fifth c.c. of ooze contained the following Protozoa:—

Rhizopoda.—1 *Difflugia globulosa*.
Mastigophora.—3 *Bodo (P.) parva*.
Infusoria.—3 *Coleps hirtus*, 1 *Paramœcium putrinum*, 2 *Stylonychia mytilus*.

It may be of interest to add that a water culture of this soil was also made for comparison. The same Protozoa as were recorded from direct examination occurred in the culture, but in addition *Amœba limax*, *Pleuromonas jaculans* and *Cyclidium glaucoma* were also seen.

(ii) Sample of soil from the edge of the swimming bath, taken three inches below the surface of the water, was examined. The soil was black, not sandy, contained vegetable débris and was foul smelling. Two samples of the ooze were examined.

(*a*) One-fifth c.c. of ooze contained:

Infusoria.—1 *Paramœcium putrinum*, 1 *Stylonychia mytilus*

(*b*) One-fifth c.c. of ooze contained one *Paramœcium putrinum* only.

A water culture of this soil showed, in addition, after 22 days, one *Paramœcium aurelia* and one *Amœba limax*.

Mulder's Drift.—A sample of soil was obtained from the bank of the drift in fine weather on September 14. It was black waterlogged soil giving a weak acid reaction to litmus. One-half c.c. of ooze contained the following Protozoa:—

Mastigophora.—2 *Euglena viridis*, 1 *Euglena oxyuris*.
Infusoria.—3 *Coleps hirtus*, 1 *Colpoda cucullus*, 8 *Cyclidium glaucoma*.

Florida.—A small sample of waterlogged soil was obtained from the banks of Florida Lake on September 19. The soil gave an acid reaction to litmus. One-fifth c.c. of ooze yielded some interesting trophic Protozoa not hitherto recorded in direct

examinations of soil from other localities in South Africa. The following organisms were observed:—

Mastigophora.—2 *Euglena oxyuris*, 1 *Petalomonas pleurosigma*, 1 *Entosiphon sulcatum*.

Infusoria.—1 *Loxophyllum rostratum*, 2 *Colpoda cucullus*, 3 *Paramœcium putrinum*.

The occurrence of *Petalomonas pleurosigma* and *Loxophyllum rostratum* is of much interest. *Entosiphon sulcatum* has been found in cultures of soils from other localities, but has not been detected in such soils by direct examinations.

Canada Junction, near Johannesburg.—One sample of waterlogged soil was obtained at the commencement of the Transvaal rainy season on November 6, after three days' heavy rain. This soil had been under water for three days. The sample was a mixed one of the first three inches of soil, from a spot ten feet from a farm dam, where normally the soil was always slightly moist.

The soil was a black loam, with some sand and much plant débris. It gave an acid reaction to litmus. Samples of one-half c.c. of ooze from this soil were examined at intervals of four and eight hours after the sample had been collected. The following Protozoa in the trophic condition were observed:—

Rhizopoda.—1 *Amœba verrucosa*, 1 *Euglypha* sp.

Mastigophora.—2 *Oikomonas termo*, 2 *Bodo* (*P.*) *parva*.

Infusoria.—3 *Lacrymaria olor*, 1 *Cyclidium glaucoma*.

Two cysts of *Amœba verrucosa* were also found, in addition to the trophic motile specimen. Practically no difference was noted in the ooze examined at four hours and at eight hours.

Milner Park, Johannesburg.—This sample was collected on November 8 from the side of a donga in which three inches or more of rain had lain for a week. The fluid that oozed from the feebly acid, brownish red sandy loam was examined, and the following Protozoa were found in one-half c.c. of the ooze:—

Mastigophora.—5 *Bodo* (*P.*) *parva*, 2 *Oikomonas termo*, 1 *Peranema trichophorum*.

Infusoria.—2 *Colpoda cucullus*, 1 *Paramœcium aurelia*.

Geographical Distribution of Protozoa as Ascertained by Cultures of Non-Waterlogged Soils.

The geographical distribution of Protozoa in South African soils recorded by us last year (this Journal, vol. XVIII, pp. 382-385) can now be amplified and extended by the addition of other localities and the inclusion of organisms not listed heretofore.

Rhizopoda.

Amœba proteus, found in soils from Gwaayang (George district), Jonkersberg (good and poor pine lands), Potchefstroom, Onderstepoort, Glen (locality iv), Bloemfontein (cultivated and uncultivated soils), Lourenço Marques (Observatory and Botanic Gardens).

Amœba limax, found in soils from Rosebank, Gwaayang, Onderstepoort, Winburg (cultivated soil), Glen

(locality v), Bloemfontein (cultivated and uncultivated soils), Lourenço Marques (Observatory), Marracuene.

Amœba radiosa, found in soils from Onderstepoort, Lourenço Marques (Observatory).

Amœba verrucosa, found in soils from Rosebank, Gwaayang, Glen (locality iii), Lourenço Marques (Observatory).

Amœba guttula, found in soils from Rosebank, Gwaayang, Jonkersberg (good and poor pine lands), Potchefstroom, Onderstepoort (near post-mortem hall), Glen (localities i, iv, v, vi), Bloemfontein (uncultivated), Lourenço Marques (Observatory).

Arcella vulgaris, found in soil from Johannesburg, Onderstepoort (near post-mortem hall).

Difflugia globulosa, found in soils from Rosebank, Potchefstroom, Jonkersberg (good and poor pine lands), Winburg (cultivated and uncultivated), Bloemfontein (uncultivated), Onderstepoort, Lourenço Marques (Observatory).

Difflugia pyriformis, found in soil from Johannesburg.

Euglypha alveolata, found in soils from Rosebank, Jonkersberg (good and poor pine lands), Glen (locality iv), Lourenço Marques (Observatory).

Euglypha sp., found in soils from Rosebank, Gwaayang, Jonkersberg (good and poor pine lands), Grootfontein (Virgin Red Karroo), Potchefstroom, Onderstepoort, Winburg (cultivated and uncultivated), Glen (localities i—vi), Bloemfontein (cultivated and uncultivated), Lourenço Marques (Observatory and Botanic Gardens), Marracuene.

Heliozoa.

Actinophrys sol, found in soils from Gwaayang, Jonkersberg (good and poor pine lands), Bloemfontein (uncultivated), Potchefstroom, Onderstepoort, Lourenço Marques (Observatory), Marracuene.

Acanthocystis aculeata, found in soil from Winburg (uncultivated).

Mastigophora.

Mastigamœba sp., found in soils from Rosebank, Winburg (uncultivated).

Peranema trichophorum, found in soils from Rosebank, Gwaayang, Jonkersberg (good pine land), Grootfontein (Virgin Red Karroo and Cultivated Red Karroo), Potchefstroom, Winburg (cultivated), Glen (localities ii to vi), Bloemfontein (cultivated and uncultivated), Lourenço Marques (Observatory).

Oikomonas termo, found in soils from Rosebank, Gwaayang, Jonkersberg (good and poor pine lands), Johannesburg, Winburg (cultivated and uncultivated), Glen (localities i—vi), Bloemfontein (cultivated and uncultivated), Lourenço Marques (Observatory and Botanic Gardens), Marracuene.

Euglena viridis, found in soils from Rosebank, Lourenço Marques (Observatory).

Euglena spirogyra, found in soil from Winburg (uncultivated).

Euglena oxyuris, found in soils from Rosebank, Jonkersberg (good and poor pine lands), Bloemfontein (cultivated), Lourenço Marques (Observatory).

Herpetomonas terricolæ, found in soils from Rosebank, Glen (localities v, vi), Lourenço Marques (Observatory).

Cercomonas crassicauda, found in soils from Gwaayang, Jonkersberg (good pine land), Grootfontein (cultivated Red Karroo), Winburg (uncultivated).

Bodo (P.) parva, found in soils from Rosebank, Gwaayang, Jonkersberg (good and poor pine land), Grootfontein (cultivated Red Karroo), Onderstepoort, Winburg (cultivated and uncultivated), Glen (localities i—vi), Bloemfontein (cultivated and uncultivated), Lourenço Marques (Observatory and Botanic Gardens), Marracuene.

Pleuromonas jaculans, found in soils from Rosebank, Gwaayang, Grootfontein (Virgin Red Karroo and cultivated Red Karroo), Potchefstroom, Onderstepoort, Winburg (cultivated and uncultivated), Glen (localities i, ii, iv, vi), Bloemfontein (cultivated).

Entosiphon sulcatum, found in soils from Gwaayang, Jonkersberg (good and poor pine lands), Potchefstroom, Glen (locality ii), Bloemfontein (uncultivated), Lourenço Marques (Observatory).

Infusoria.

Holophrya ovum, found in soils from Rosebank, Winburg (uncultivated), Glen (locality i), Lourenço Marques (Observatory).

Lacrymaria olor, found in soils from Rosebank, Jonkersberg (good pine land), Winburg (cultivated), Glen (localities i, ii), Lourenço Marques (Observatory and Botanic Gardens).

Coleps hirtus, found in soils from Grootfontein (cultivated Red Karroo), Lourenço Marques (Observatory).

Prorodon ovum, found in soil from Rosebank.

Amphileptus cygnus, found in soils from Jonkersberg (poor pine land), Glen (locality i), Bloemfontein (cultivated), Lourenço Marques (Observatory).

Lionotus fasciola, found in soil from Glen (locality vi).

Colpidium colpoda, found in soil from Winburg (cultivated)

Colpidium striatum, found in soils from Rosebank, Winburg (uncultivated).

Colpoda cucullus, found in soils from Rosebank, Jonkersberg (good pine land), Winburg (cultivated), Glen (localities i, iii), Lourenço Marques (Observatory and Botanic Gardens).

Paramœcium aurelia, found in soil from Rosebank, Jonkersberg (good pine land), Glen (localities i, iv), Bloemfontein (uncultivated).

Paramœcium putrinum, found in soil from Rosebank.

Cyclidium glaucoma, found in soils from Rosebank, Gwaayang, Jonkersberg (good pine land), Grootfontein (virgin and cultivated Red Karroo), Winburg (cultivated and uncultivated), Glen (localities i—vi), Bloemfontein (uncultivated), Lourenço Marques (Observatory).

Spirostomum ambiguum, found in soils from Winburg (uncultivated), Lourenço Marques (Observatory).

Halteria grandinella, found in soils from Potchefstroom, Glen (locality v).

Stylonychia mytilus, found in soils from Rosebank, Jonkersberg (good pine land), Onderstepoort, Winburg (uncultivated), Lourenço Marques (Observatory and Botanic Gardens).

Aspidisca costata, found in soil from Lourenço Marques (Botanic Gardens).

Euplotes harpa, found in soils from Rosebank, Johannesburg, Glen (locality iv), Lourenço Marques (Observatory and Botanic Gardens).

Uroleptus piscis, found in soils from Rosebank, Potchefstroom, Lourenço Marques (Observatory and Botanic Gardens).

Vorticella campanula, found in soils from Rosebank, Jonkersberg (good pine land), Onderstepoort, Winburg (uncultivated).

List of Trophic Protozoa so far Found in Waterlogged Soils.

Last year, in this Journal, pp. 385-6, notes were given of the trophic Protozoa found in some waterlogged soils on direct examination. Further examinations of waterlogged soils have been made, of which accounts are given in this paper (see pp. 354-5). The two series of results are now collated and summarised in respect to the distribution of the trophic Protozoa in the waterlogged soils examined.

Rhizopoda.

Amœba proteus, found in waterlogged soil from the ditch of the Fort, Johannesburg.

Amœba limax, found in waterlogged soil from Bedford Court.

Amœba verrucosa, found in waterlogged soil from Canada Junction.

Amœba radiosa, found in waterlogged soil from a storm water ditch, a land drain and the ditch of the Fort, Johannesburg; Sans Souci dam.

Difflugia globulosa, found in waterlogged soil from Bedford Court.

Euglypha sp., found in waterlogged soil from Canada Junction.

Mastigophora.

Peranema trichophorum, found in waterlogged soil from Milner Park, Johannesburg.

Oikomonas termo, found in waterlogged soil from a storm water ditch, a land drain, the ditch of the Fort, flooded mealie land, and Milner Park, Johannesburg; Sans Souci dam, Canada Junction.

Bodo (P.) parva, found in waterlogged soil from a storm water ditch, a land drain, the ditch of the Fort, flooded mealie land, and Milner Park, Johannesburg; Bedford Court, Sans Souci dam, Canada Junction.

Euglena viridis, found in waterlogged soil from a storm water ditch, a land drain, the ditch of the Fort, flooded mealie land, Johannesburg; Mulder's Drift.

Euglena oxyuris, found in waterlogged soil from Mulder's Drift, Florida.

Petalomonas pleurosigma, found in waterlogged soil from Florida.

Entosiphon sulcatum, found in waterlogged soil from Florida.

Pleuromonas jaculans, found in waterlogged soil from Bedford Court.

Infusoria.

Holophrya ovum, found in a storm water ditch, a land drain and the ditch of the Fort, Johannesburg.

Lacrymaria olor, found in waterlogged soil from Canada Junction.

Coleps hirtus, found in waterlogged soil from the ditch of the Fort, Johannesburg; Sans Souci dam, Bedford Court, Mulder's Drift.

Loxophyllum rostratum, found in waterlogged soil from Florida.

Colpoda cucullus, found in waterlogged soil from Mulder's Drift, Milner Park, Johannesburg; Florida.

Colpidium striatum, found in storm water ditch, Johannesburg.

Paramœcium aurelia, found in waterlogged soil from flooded mealie land and Milner Park, Johannesburg; Bedford Court.

Paramœcium putrinum, found in waterlogged soil from Bedford Court, Florida.

Cyclidium glaucoma, found in waterlogged soil from the ditch of the Fort, Johannesburg, Sans Souci dam, Mulder's Drift, Canada Junction, Bedford Court.

Stylonychia mytilus, found in waterlogged soil from Bedford Court.

Vorticella campanula, found in waterlogged soil from the ditch of the Fort, Johannesburg, Sans Souci dam.

Environmental Effects.

Some further observations were made on the effects of variation of environment on the Protozoa in the soil.

Influence of Depth of Soil.

For this purpose, a compact block of soil, twelve inches deep, was divided into twelve slabs, each slab or layer being one inch in depth, great care being taken to avoid any mixing of the layers. The soil was from the Rosebank Experimental Station (Liesbeek alluvial), and its protozoal content, as shown in cultures of each layer, is given on pp. 342-4. A composite sample was also examined. A summary of the organisms at each depth is given in tabular form (Table II), each successive inch layer being numbered 1 to 12 and the composite sample being numbered 13.

TABLE II.

LIESBEEK SOILS.

Protozoa observed.	DEPTH OF SOIL SAMPLE IN INCHES.												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Amoeba proteus	1		1	1				1			1		
Amoeba limax	1	1	1	1	1	1		1	1	1	1		1
Amoeba guttula	1	1		1	1			1	1	1	1		
Difflugia globulosa						1		1					
Euglypha alveolata				1				1					
Euglypha sp.	1	1	1	1	1	1	1	1	1	1	1	1	1
Actinophrys sol				1	1				1				1
Mastigamoeba sp.	1												
Peranema trichophorum ..	1	1		1		1			1				1
Oikomonas termo	1	1	1	1	1	1	1	1	1	1	1	1	1
Bodo (*Prowazekia*) *parva* ..	1	1	1		1	1	1	1	1	1		1	1
Euglena viridis				1		1	1	1		1			
Euglena oxyuris		1			1	1	1	1		1	1		
Herpetomonas terricolae ..										1			
Pleuromonas jaculans		1	1	1	1	1	1	1	1	1	1	1	1
Holophrya ovum		1			1	1		1	1	1			1
Lacrymaria olor	1	1		1		1		1			1	1	1
Prorodon ovum	1												
Colpoda cucullus					1	1			1	1	1		1
Colpidium striatum						1			1	1			1
Cyclidium glaucoma	1	1			1	1		1	1	1			1
Paramoecium aurelia		1					1				1		
Paramoecium putrinum ..		1					1				1		
Stylonychia mytilus			1	1							1	1	
Euplotes harpa			1										
Uroleptus piscis			1							1	1	1	1
Vorticella campanula	1	1					1	1			1	1	1
Total kinds of Protozoa ..	12	14	9	12	11	14	9	15	12	14	14	8	14

From the table it will be seen that two organisms only, *Euglypha* sp. and *Oikomonas termo*, persist throughout the series, though *Pleuromonas jaculans* is present in all but the surface layer of soil, and is present as deep as 12 inches from the surface of the ground. *Amœba limax*, *Bodo* (*P.*) *parva*, *Holophrya ovum*, *Cyclidium glaucoma*, *Lacrymaria olor* and *Vorticella campanula* can persist in many layers of soil to about twelve inches deep. The rarest ciliate seen, *Prorodon ovum*, occurred

in extremely small numbers only in cultures of the surface layer. Similarly, the soil *Herpetomonas* was confined to the sample of soil taken at ten inches deep, which layer was one of the richest of the series of thirteen in numbers of species of Protozoa, and was also almost the richest in total numbers of organisms present.

One feature of great interest was the finding of certain Protozoa in cultures of relatively deep soils. *Euglena viridis* and *E. oxyuris* were recognised first as green cysts in which the stigma was quite distinct. Morphologically, the cysts presented the same appearance, no matter what the depth of soil in which they occurred in the series. The maximum number of cysts, and later of motile Euglenæ, was found in cultures of soil taken at ten inches from the surface, the numbers being considerably larger than those obtained in cultures of soil taken at four, five and six inches deep. This may result from (*a*) washing down by rain of the maximum number of cysts or motile Euglenæ to the depth of ten inches, the organisms then lodging there and the trophic forms encysting, or (*b*) to selective action of the Euglenæ, that migrate to deeper soil for purposes of encystment. The latter factor seems possible, especially considering the rare occurrence of other Protozoa, such as the larger Ciliates, *Stylonychia mytilus* and *Uroleptus piscis*, in layers of soil near the surface, compared with the larger numbers observed in the deeper layers of soil.

The Rosebank Experiment Station is a convergence of the natural drainage area of the Liesbeek River. There is kaolin underneath the Rosebank district, so that there is good penetration of water into the surface soil above the kaolin. The results recorded for Rosebank in regard to the occurrence of Protozoa at various depths can perhaps hardly be considered typical for areas in general.

A comparison of the protozoal fauna of cultures of soil from the Grootfontein School of Agriculture, Middelburg, C.P., taken at six and nine inches deep, may be of interest (see Tables III, IV). As a general statement, the Protozoa were more numerous in soil at six inches deep than in soil at nine inches deep.

The Virgin Red Karroo soil at nine inches deep showed neither Amœbæ nor Difflugia, both of which occurred at a depth of six inches. Neither *Bodo* (*Prowazekia*) *parva* nor *Euglena viridis* were found at a depth of nine inches, though both were present in cultures of soil taken at six inches. Of the Ciliata, *Lacrymaria olor* is common to both depths while *Cyclidium glaucoma* was found only in the culture of the deeper soil.

In the case of the Cultivated Red Karroo soils, no Heliozoa were found in the deeper soil cultures, nor was *Euglena viridis* present. *Cercomonas crassicauda* appeared there. *Oikomonas termo* and *Bodo* (*P.*) *parva* were common to each depth. The Infusoria were different from those found in cultures of soil at six inches deep, the latter being *Lacrymaria olor*, *Colpoda steinii* or *saprophila* and *Spirostomum ambiguum*, while at nine inches deep the Ciliata were *Cyclidium glaucoma* and *Coleps hirtus*.

As in the cultures examined and reported upon last year (this Journal, Vol. XVIII, pp. 379, 380), there is a great difference

between the protozoal faunas of virgin and cultivated Karroo soils, the latter being richer in genera and also having a greater total number of Protozoa present.

A tabular comparison may also be made between the protozoal fauna of Virgin Red Karroo, Cultivated Red Karroo and Liesbeek soils, all taken at six inches and nine inches deep (Tables III and IV), the fauna of the Karroo (Grootfontein) soils at six inches being taken from last year's results, though the time of the year at which samples were taken differed.

The soil samples taken at six inches deep may be first considered.

TABLE III.

(1) SOILS AT 6 INCHES DEEP.

	Virgin Red Karroo, 6 inches deep.	Cultivated Red Karroo, 6 inches deep.	Liesbeek soil, 6 inches deep.
Rhizopoda ..	*Amoeba limax* ..	—	*Amoeba limax*
	Difflugia globulosa	—	*Difflugia globulosa*
			Euglypha sp.
Heliozoa ..	—	*Actinophrys sol* ..	—
Mastigophora	*Oikomonas termo*	*Oikomonas termo*	*Oikomonas termo*
	Bodo (*P.*) *parva*	*Bodo* (*P.*) *parva* ..	*Bodo* (*P.*) *parva*
	Euglena viridis ..	*Euglena viridis* ..	*Euglena viridis*
	—	—	*Euglena oxyuris*
			Peranema trichophorum
			Pleuromonas jaculans
Infusoria ..	*Lacrymaria olor*	*Lacrymaria olor* ..	*Lacrymaria olor*
			Holophrya ovum
			Cyclidium glaucoma
		Colpoda steinii ..	*Colpoda cucullus*
		—	*Colpidium striatum*
		Spirostomum ambiguum	—

From the table it is seen that Virgin Red Karroo and Liesbeek soils at six inches deep have two Rhizopoda in common, namely, *Amœba limax* and *Difflugia globulosa*, neither of which is represented in Cultivated Red Karroo soil at the same depth.

In regard to Mastigophora, *Oikomonas termo*, *Bodo* (*Prowazekia*) *parva* and *Euglena viridis* are common to all three soils.

Among the Infusoria, *Lacrymaria olor* is present in all three soils at six inches depth. The Liesbeek soil contains more genera and species of Protozoa than the others. It seems, however, that *Oikomonas termo*, *Bodo* (*P.*) *parva*, *Euglena viridis* and *Lacrymaria olor* persist in each soil, irrespective of their comparative physical condition, and may, perhaps, provisionally be considered as normal Protozoal inhabitants of soil at six inches deep.

The samples of these soils taken at a somewhat deeper level (nine inches) may next be considered.

TABLE IV.
(2) SOILS AT 9 INCHES DEEP.

	Virgin Red Karroo, 9 inches deep.	Cultivated Red Karroo, 9 inches deep.	Liesbeek Soil, 9 inches deep.
Rhizopoda..	—	*Amoeba limax* ..	*Amoeba limax*
	—	—	*Amoeba guttula*
	Euglypha sp. ..	*Euglypha* sp. ..	*Euglypha* sp.
Heliozoa ..	—	—	*Actinophrys sol*
Mastigophora	*Peranema trichophorum* ..	*Peranema trichophorum* ..	*Peranema trichophorum*
	Oikomonas termo	*Oikomonas termo*	*Oikomonas termo*
	—	*Bodo (P.) parva* ..	*Bodo (P.) parva*
	Pleuromonas jaculans ..	*Pleuromonas jaculans* ..	*Pleuromonas jaculans*
	—	*Cercomonas crassicauda*	—
Infusoria ..	*Lacrymaria olor*	—	—
	Cyclidium glaucoma	*Cyclidium glaucoma*	*Cyclidium glaucoma*
	—	*Coleps hirtus* ..	—
	—	—	*Holophrya ovum*
	—	—	*Colpoda cucullus*
	—	—	*Colpidium striatum*

The comparison of the fauna of the three soils again shows the presence of Protozoa common to each. These are *Euglypha* sp., *Oikomonas termo*, *Peranema trichophorum*, *Pleuromonas jaculans* and *Cyclidium glaucoma*. It is of interest to note that the species of Protozoa common to these soils at six inches deep are different from those common to each kind of soil at nine inches deep, *Oikomonas termo* excepted.

Influence of Culture Area Exposed on the Number of Protozoa Observed.

Cultures of equal quantities of soil and water were made in vessels of different diameters, in an endeavour to estimate what influence, if any, the surface area of soil exposed to the direct action of the water had on the rate of development of trophic Protozoa.

Thus, three cultures were made of soil from a Stellenbosch vineyard—soil known to be rich in Protozoa; different sized vessels were employed, and the results were as follow:—

(1) A culture of 5 grams of soil in 10 c.c. of boiled sterile water was made in a test tube of 17·5 mm. diameter. On examination after six days of culture, one-half c.c. of the fluid yielded the following trophic Protozoa:—4 *Mastigamœba* sp., 2 *Euglypha* sp., 18 *Pleuromonas jaculans*, 16 *Cyclidium glaucoma*.

(2) A similar culture made on the same date in a small Petri dish of 32 mm. diameter, was examined on the same day as culture (1). One-half c.c. of the fluid yielded:—1 *Difflugia pyriformis*, 8 *Mastigamœba* sp., 5 *Euglypha* sp., 52 *Pleuromonas jaculans*, 20 *Cyclidium glaucoma*.

(3) Another similar culture in a flask of 62·5 mm. diameter, made at the same time and examined at the same time as the other cultures, showed a still further increase, the Protozoa found in one-half c.c. of the culture being:—2 *Amœba proteus*, 1 *Difflugia pyriformis*, 1 *Hyalosphenia elegans*, 8 *Euglypha* sp., 13 *Mastigamœba* sp., 60 *Pleuromonas jaculans* and 31 *Cyclidium glaucoma*.

From this experiment, it seems possible that shallow cultures of soil are likely to yield more Protozoa quickly than deep cultures, perhaps due to better aeration, but the matter is under further investigation by us, and the present statement is tentative.

Effect of Light

In continuation of our previous experiments (see this Journal, XVIII, p. 388), some parallel cultures of soil were kept in the light and in a dark, well ventilated cupboard respectively, and were examined daily. Light and darkness appeared to have very little influence on the development of the contained Protozoa, as the same organisms appeared in each culture on the same day.

However, one interesting effect was noticed in the case of *Hyalosphenia elegans*, from a culture of Stellenbosch soil reported on last year. When cultures containing this organism and kept in the dark were examined, it was noted that sometimes the organism put out pseudopodia, which was very seldom seen in Hyalosphenia from a culture kept in the light. This, perhaps, was a response to the sudden stimulus of light.

The Distribution of Protozoa in the Culture Fluid.

It has been stated by some American workers that certain Protozoa occur in all parts of the culture fluid. It may be of interest to note the distribution as found in some cases of soil cultures in South Africa. New cultures were made for these experiments, and soils were used that were known, from our previous experience, to be relatively rich in Protozoa. The culture tubes contained one inch of soil, above which were three inches of water, making a depth of four inches in all. The areas of the culture tube are designated surface film, middle layer, and soil layer respectively. A few typical results may be cited:—

(1) Culture of soil from St. James.
Surface film.—Many *Amœba proteus*, a few *Mastigamœba* sp.
Middle layer.—Negative for Protozoa.
Soil layer.—Very few *Amœba proteus*, *Mastigamœba* sp., *Euglypha* sp., *Cyclidium glaucoma*.

(2) Culture of soil from Heathfield, C.P.
Surface film.—*Amœba proteus*, fairly numerous *Pleuromonas jaculans*.
Middle layer.—Very few *Pleuromonas jaculans*.
Soil layer.—Very few *Amœba proteus*, *Pleuromonas jaculans*, *Cyclidium glaucoma*.

(3) Culture of soil from Onderstepoort.

Surface film.—*Amœba proteus*, *Oikomonas termo*, *Uroleptus piscis*, all in small numbers.

Middle layer.—*Cyclidium glaucoma*, *Holophrya ovum*, a single specimen of each.

Soil layer.—*Euglypha* sp., *Oikomonas termo*, *Cyclidium glaucoma*, and *Holophrya ovum* in small numbers.

From these preliminary experiments, it seems that the conclusion may be provisionally reached that Amœbæ occur more commonly in the surface film of water and Ciliates are more abundant in the soil layer. Possibly these Amœbæ are more ærobic than the Ciliates. These ideas are borne out by other observations, and, in estimating the numbers of organisms in any one culture, we have always endeavoured to examine samples including surface film, middle layer and soil layer.

Sequence of Appearance of Protozoa in Cultures of Soil from Different Depths.

A series of observations was made on the sequence of appearance of the different Protozoa in cultures of Rosebank (Liesbeek) soil taken at successive inch depths, the soils being numbered 1 to 12, as previously, and 13 being a composite sample. The Protozoa found therein have already been listed in Table II. The day of culture on which each Protozoon first appeared at any given depth is indicated in Table V by a number in the column opposite its name (see next page). The period of observation extended over 93 days.

From consideration of Table V, several inferences may be made in regard to sequence of appearance of Protozoa in cultures and to the succession of the Protozoa in any one soil. Thus, the Flagellata, *Oikomonas termo*, *Bodo* (*P.*) *parva* and *Pleuromonas jaculans* appear in most of the depth cultures at really early dates, though there are exceptions in each case. On the other hand, the Flagellate, *Peranema trichophorum*, approaches more nearly to the Rhizopoda in its date of appearance; its earliest appearance being 44 days after culture, while it has appeared 88 days after the culture was made. When *Euglena viridis* and *E. oxyuris* have occurred in the same culture, *E. viridis* has appeared a good deal earlier than *E. oxyuris*. It has also died out sooner.

As a general statement, the Flagellata appear to develop relatively early in cultures from any depth of soil, *Euglena viridis* and *E. oxyuris* being exceptions and appearing relatively late.

Among the Infusoria, the organisms appearing early in cultures were *Lacrymaria olor*, *Cyclidium glaucoma*, *Vorticella campanula* and *Colpidium striatum*. On the other hand, *Paramœcium aurelia*, *P. putrinum* and *Uroleptus piscis* made their first appearance very late.

TABLE V

LIESBEEK SOILS.

Protozoa observed.	First day of appearance at successive depths of soil.												
	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13
Amoeba proteus	9	—	39	40	—	—	—	47	—	—	57	—	—
Amoeba limax ..	49	36	36	17	40	36	—	64	44	36	18	—	17
Amoeba guttula	77	38	—	55	62	—	—	47	69	41	69	—	—
Difflugia globulosa ..	—	—	—	—	—	33	—	79	—	—	—	—	—
Euglypha alveolata	—	—	—	84	—	—	—	79	—	—	—	—	—
Euglypha sp. ..	2	16	5	2	11	5	55	6	5	15	14	16	4
Actinophrys sol	—	—	—	62	50	—	—	—	69	—	—	—	15
Mastigamoeba sp.	69	—	—	—	—	—	—	—	—	—	—	—	—
Peranema trichophorum	88	46	—	62	—	47	—	—	55	—	—	—	44
Oikomonas termo	9	4	8	17	6	12	13	54	7	16	4	11	11
Bodo (P.) parva	2	9	5	—	14	47	8	6	7	36	—	14	3
Euglena viridis	—	—	—	69	—	48	50	59	—	58	—	—	—
Euglena oxyuris	—	71	—	—	72	62	64	65	—	72	58	—	—
Herpetomonas sp.	—	—	—	—	—	—	—	—	—	18	—	—	—
Pleuromonas jaculans ..	—	5	2	5	5	6	46	5	4	4	7	6	5
Holophrya ovum	—	69	—	—	38	12	—	8	44	44	—	—	5
Lacrymaria olor	2	2	—	41	—	12	—	13	—	—	4	13	13
Prorodon ovum	47	—	—	—	—	—	—	—	—	—	—	—	—
Colpoda cucullus	—	—	—	—	85	6	—	—	6	15	9	—	8
Colpidium striatum ..	—	—	—	—	—	6	—	—	5	7	—	—	7
Cyclidium glaucoma ..	5	14	—	—	14	5	—	9	17	36	—	—	5
Paramoecium aurelia ..	—	83	—	—	—	—	85	—	—	—	57	—	—
Paramoecium putrinum ..	—	69	—	—	—	—	70	—	—	—	72	—	—
Stylonychia mytilus ..	—	—	59	18	—	—	—	—	—	—	74	13	—
Euplotes harpa	—	—	75	—	—	—	—	—	—	—	—	—	—
Uroleptus piscis	—	—	69	—	—	—	—	—	—	54	69	58	72
Vorticella campanula	36	7	—	—	—	—	6	15	—	—	7	8	18

Of the three species of Amœbæ found in these cultures, *Amœba proteus* was sometimes the pioneer, and was the only one to assume even subdominance. *Amœba limax* occupied the intermediate period for development, while *Amœba guttula* was the last to appear.

The thecamœba, *Euglypha* sp., appeared early. *Euglypha alveolata* was much less common and appeared late in culture, as did the other representative of the group, *Difflugia globulosa*.

The composite sample, Liesbeek 13, in addition to containing representatives of practically all the commoner Protozoa observed, appears to have shown development of them relatively early, and in some cases, for example, *Cyclidium glaucoma*, *Peranema trichophorum*, *Holophrya ovum*, *Actinophrys sol*, the Protozoa were observed in the culture of the composite sample before they were seen in the cultures of the individual soil layers.

The Succession of Dominant Types.

In each culture examined, it has been found that for varying periods one species of Protozoon outnumbers the rest, and hence may be termed the dominant type for the time being. If charts are constructed of the number of each kind of organism observed daily in a measured quantity of culture, the succession of dominant types can be determined. This succession varies with the different soils.

For example, in an examination of soil from the Observatory Garden at Lourenço Marques over a period of 79 days, *Euglypha* sp. was the dominant organism for the first 47 days, when *Peranema trichophorum* equalled it in numbers for three days, and after three days more became dominant. After yet another three days, the number of Peranema had fallen greatly, and the Euglypha reassumed dominance. On the 62nd day, *Amœba proteus* suddenly became dominant and retained its dominance for four days, after which time *Amœba proteus* and *Peranema trichophorum* were dominants alternately.

Secondary or sub-dominants were also noted. Thus, at a period when *Euglypha* sp. was markedly dominant, *Amœba proteus* and *Peranema trichophorum* were almost equal in numbers and their graphs were parallel. They definitely were subdominant to the Euglypha. Later, when *Peranema trichophorum* was dominant, *Amœba proteus* became subdominant, and when *Amœba proteus* in turn became dominant, *Cyclidium glaucoma* became its subdominant.

The succession of dominants in cultures of Liesbeek 14 soil is interesting. For the first ten days, *Euglypha* sp. was the most abundant organism and was dominant. Then *Euglena oxyuris* suddenly assumed dominance and retained it for twelve days. *Actinophrys sol* next became dominant, but for two days only, when *Euglena oxyuris* regained numerical supremacy for five days. The flagellate was then replaced as dominant in numbers for one day by *Amœba proteus*, then regained its position as dominant for five days, when *Actinophrys sol* attained equal numbers. This, however, was not maintained, and *Euglena oxyuris* again became the dominant organism in the culture and remained so for twenty-eight days.

Euglypha sp. was the most marked subdominant in this culture, *Amœba proteus* being far less numerous.

In the two cases investigated, namely, in soils from Lourenço Marques Observatory Garden and Liesbeek 14, the sequence of group dominants in each appears roughly to be Thecamœbæ, Flagellata and Rhizopoda.

Sporadic Appearances of Protozoa in Cultures.

As mentioned in our previous paper, sometimes a Protozoon appears in a culture on a certain day and then disappears for a considerable period. Usually such organisms are few in number, frequently only occurring singly in the specimen examined at any one time.

Holophrya ovum, one of the ciliates more rarely observed, exhibited this peculiarity. Thus, in the culture of the Liesbeek soil taken at six inches deep, *H. ovum* appeared on the twelfth day. It disappeared the next day and was not seen again until the 95th day of culture.

Prorodon ovum appeared once in the culture of Liesbeek soil of one inch depth on the 47th day of culture and has not been seen since.

Entosiphon sulcatum appeared in a culture of soil from the Observatory Garden, Lourenço Marques, on the seventh day of culture. It was present in very small numbers, had entirely disappeared next day, and has not reappeared since.

Coleps hirtus, again, was erratic. In cultures of soil from Lourenço Marques, it appeared in very small numbers on days 7, 8, 22, 37, 38, 39, 45, 50, 51, 62 and 63, and was absent during the intervening periods.

Another case of interest is where an organism appears early in cultures and is practically the dominant or subdominant for a short time. It then disappears and only reappears again sporadically and often only in units. *Cyclidium glaucoma* fairly often has behaved in this manner in our cultures.

Two suggestions may be made to explain this sporadic appearance of certain trophic Protozoa in soil cultures. Possibly but few encysted organisms are present in the soil. Those that excyst early either seem unable to persist and multiply and the reappearances are due to later excystation of contemporaneous cysts, or multiplication of trophic forms may be immediately followed by encystment, when the newly-formed cysts provide the succeeding sporadic trophic Protozoa. The existence of small strains of various Protozoa in soil cultures has been often noticed by us, and may have arisen in the way indicated, or they may represent definite small strains or varieties.

It is obvious that detailed daily examinations are necessary if the true protozoal fauna of any soil is to be accurately ascertained.

Seasonal Variation in the Protozoal Fauna of Certain Soils.

A few observations have been made in connection with the possible influence of the season of the year on the protozoal fauna of certain soils, though, unfortunately, the depths at which the soil samples were taken for us were not always the same.

Thus, samples of Virgin Red Karroo soil and Cultivated Red Karroo soil, at a depth of six inches, collected on September 29 at the Grootfontein School of Agriculture, Middelburg, were reported on, as to protozoal content, in this Journal, Vol. XVIII, pp. 379-380. The previous findings may be compared with those now recorded, as the second samples were taken on April 11, 1922, at approximately the same spots where the previous samples were obtained, but at nine inches deep. Six months' interval occurred between the collecting of the two samples, and the results may be presented in tabular form (Tables VI and VII).

Virgin Red Karroo Soil.

TABLE VI

Class of Protozoon.	Protozoa found in Soil collected in September.	Protozoa found in Soil collected in April.
Rhizopoda	*Amoeba limax*	—
	Difflugia globulosa	—
	—	*Euglypha sp.*
	Oikomonas termo	*Oikomonas termo*
Mastigophora ..	*Bodo (Prowazekia) parva*	—
	Euglena viridis	—
	—	*Peranema trichophorum*
	—	*Pleuromonas jaculans*
Infusoria	*Lacrymaria olor*	*Lacrymaria olor*
	—	*Cyclidium glaucoma*

It is seen, then, that two organisms only, namely, *Oikomonas termo* and *Lacrymaria olor*, are common to each season. *Amœba limax* occurs in spring (September) samples, but not in autumn (April) collected soil. Different thecamœbæ occurred. The flagellate, *Peranema trichophorum*, was found in the April and not in the September sample, but in the latter, large specimens of *Euglena viridis* occurred, but were absent from the April sample. There was then a marked difference between spring and autumn protozoal fauna in Virgin Red Karroo soil.

Cultivated Red Karroo Soil.

TABLE VII

Class of Protozoon.	Protozoa found in Soil collected in September.	Protozoa found in Soi collected in April.
Rhizopoda	—	*Amoeba limax*
		Euglypha sp.
Heliozoa	*Actinophrys sol*	—
Mastigophora	*Oikomonas termo*	*Oikomonas termo.*
	Bodo (Prowazekia) parva	*Bodo (Prowazekia) parva*
	Euglena viridis	—
	—	*Peranema trichophorum*
	—	*Cercomonas crassicauda*
	—	*Pleuromonas jaculans*
Infusoria ..	*Lacrymaria olor*	—
	Colpoda steinii	—
	Spirostomum ambiguum	—
	—	*Coleps hirtus.*
	—	*Cyclidium glaucoma*

From Table VII it is seen that two Protozoa occur in soil samples taken in both spring and autumn, namely, the flagellates, *Oikomonas termo* and *Bodo* (*P.*) *parva*. The remaining Protozoa differ widely from one another. In autumn there are more kinds of Flagellates present in Cultivated Red Karroo soil than in spring. Apparently a different protozoal fauna may be expected in spring from what is present in autumn.

Summary.

(1) In continuation of our previous work, examinations have been made of more South African soils from the Cape Province; Transvaal and Orange Free State. Some soils from the south of Portuguese East Africa have also been examined. Direct examinations and water cultures have been used throughout. The list of genera and species of Protozoa recorded from soils in our previous communication has been extended.

A *Herpetomonas*, named *H. terricolæ* (see p. 344), was found in samples of soil from Rosebank (Liesbeek), C.P., from infertile patches at Glen, and from the Observatory Garden at Lourenço Marques.

(2) The geographical distribution of the different genera and species of Protozoa of the soils examined by us has been extended (see p. 355), and a list of the trophic Protozoa found by direct examination in waterlogged soils by us is appended (see p. 358).

(3) Compared with our results of last year, an increase in the number of genera and species of Protozoa in waterlogged soils has been observed.

(4) Study of the influence of various environmental effects has been continued. Interesting results were obtained in regard to the influence of the depth of soil on the numbers and nature of the Protozoa contained therein. A block of soil from the surface to twelve inches deep, cultured in successive inch layer samples, had *Euglypha* sp. and *Oikomonas termo* as the only organisms found in each layer of the series. A soil *Herpetomonas* was found in the layer of soil taken at ten inches deep. In cultures of relatively deep soil, cysts and trophic forms of *Euglena viridis* and *E. oxyuris* were found.

Cultures of virgin and cultivated Karroo soil, taken at six and nine inches deep, showed differences in numbers of both organisms and genera. These Karroo soils compared with one another and with Liesbeek soil taken at six inches deep showed that three Flagellates and one Ciliate were common to each soil. The other Protozoa showed divergence. The same three soils, taken at nine inches deep, contained one thecamœba, three Flagellates and one Ciliate in common, but these organisms common to each soil were almost entirely different from those common to the same soils taken at six inches deep (see Tables III, IV).

The culture area exposed appears to influence the number of trophic Protozoa detected, shallow cultures yielding more organisms than deeper ones (see p. 363).

Darkness and light appeared to have little influence on the rate of development of Protozoa in our cultures, except that *Hyalosphenia elegans* appeared to react to the sudden application of light.

The distribution of the Protozoa in the culture fluid was investigated. A few typical examples only are cited, and it is considered that in order to obtain a true estimate of the protozoal population of a culture it is necessary for the sample to include some of the surface film, middle layer and soil layer of culture fluid (see p. 364).

(5) Among the soils examined, up to the present, fertile soils appear to contain larger numbers of individual Protozoa than infertile soils. This general statement applies to soils from Glen, in the Free State, where there are infertile patches, and to soils from George, where suitability or otherwise for growing pine trees is concerned.

As regards Glen soils, differences in the species of Amœbæ found in the various samples may be noted, while in the case of George soils differences in the Ciliata are of interest.

Cultivated soils, in general, if not yielding more species of Protozoa than uncultivated soils, yet yielded more Protozoan individuals in cultures.

(6) The sequence of the appearance of Protozoa in cultures of soil from different depths has been tabulated (see pp. 365-6). The Flagellata appear to develop relatively early in cultures from any depth of soil, *Euglena viridis* and *E. oxyuris* being exceptions and appearing relatively late. *E. oxyuris* is more longlived in cultures than *E. viridis*. Some Ciliata appear much earlier in cultures than others. *Amœba proteus* sometimes appeared earlier in cultures than other species of amœbæ.

(7) The succession of dominant Protozoa has been studied in cultures of some soils. Secondary or subdominants also occur. These are discussed on p. 367.

(8) Certain Protozoa have appeared sporadically in cultures, and notes are given of the times of their appearances (see p. 367).

(9) Seasonal variation in the protozoal fauna of certain soils is indicated.

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HOTTENTOT PLACE NAMES.—II.

BY

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Read July 10, 1922.

As was pointed out in my previous paper* on the above interesting subject, there are a great many Hottentot Place Names that have disappeared from the maps, which have nevertheless been preserved for us in the records which explorers and travellers have left us of their various journeys In not a few cases the forms which are given to these place names by the writers would be exceedingly puzzling, so much so as almost to defy the possibility of either identification or elucidation. Fortunately, however, for us, they have furnished us, in a good number of instances, with the meanings of the names in either Dutch or English, with the result that if we cannot actually reconstruct many of them, we can refer them to the Hottentot words from which the place names were derived.

In pursuit of this line of study, a recent careful reading of the records left us of a few of the most important of the early journeys of sub-continental exploration, have produced very encouraging results. To mention one or two, the journals of Ensign Beutler's journey up the south-east coast to beyond the Great Kei in 1752, Governor Joachim Plettenberg's journey to the Great Fish River in 1778 (both of which are given in the original Dutch in Theal's "Belangrijke Historische Dokumenten," Nos. 1 and 2 of which were published in 1896), and Sir James Alexander's "Expedition of Discovery into the Countries of the Great Namaquas, Boschmans, and Hill Damaras," published in 1836. Beside these valuable documents, Horne's "Map of the Colony of the Cape of Good Hope and neighbouring Territories," 1895 (which gives 109 pure Hottentot place names in that part of Great Namaqualand which it embraces, and many more in Little Namaqualand), and Krönlein's "Wortschatz der Khoi-Khoin" are well worth the closest study.

In Beutler's *Journaal* at least thirty Hottentot place names are given, of which more than half are translated. In Plettenberg's "Dagverhaal," there are over twenty such names, of which eight are translated; in Alexander's two volumes no less than one hundred and twenty Hottentot place names are recorded, nearly all of which are either translated or explained.

My purpose in this paper is to deal with a selection of these names, and with a few others that have some special interest.

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* This JOURNAL, vol. xvii, pp. 334—352 (1920).

BEUTLER, 1752.

It is possible, with little trouble, to trace on a good map the course of Beutler's journey as far as the Great Kei river, by the names which he mentions of rivers and other natural features, but after he has got beyond the Kei, it is very difficult to follow him except in a very general way. He tells us that he passed into the " Tamboegies land "—here the place names that he gives are, some of them, certainly of their own coining, as Spekberg, Coperberg; others do not disclose their identity until we pick him up again well on his return journey.

In his forward journey, Beutler mentions the Gourits, Gamtousch, Cannasland and Cannasgebergte; concerning the last he says:

" . . . genoemt weegens een seeker gewas dat de Hottentotten Canna noemen, sijnde een sterk purgeermiddel . . . dit gewas siet er uijt omtrend als het lof van een Hottentots vijge, dogveel klynder dragende eene geel bloem."

The name Kanna is applied to several species of *Salsola*, as *S. aphylla*, *S. fortida* (Kannabosch). Farther on we have the place name *Koernoe* (our Coerney, Uitenhage district, C.P.). Of this name Beutler gives the following explanation:

" Een plaats door de Hottentotten *Koernoe* genaamt beyterkende soo veel als smal Bosch, dog wij noemden deese plaats Hoender craal om de menigte van Ternataalsche hoenders die sig alhier ophouden."

On Hall's " Map of the Eastern Province of the Cape of Good Hope," 1856, the Coerney river is named the " Kromme R." and on an earlier map by Arrowsmith of " The Cape of Good Hope " we find: " *Kromme* or *Kournay R.*"

Beutler does not help regarding the meaning of the place name *Keiskamma*, but he gives an interesting fact concerning it. He says:

" Arriveerden s'middags voor de Chijs Chamma rivier, dewelke soowel door de Caffers als de Hottentotten met den eigensten naam word genoemt."

Kragga Kamma was dealt with in the previous paper (*S.A. Journ. Sc.*, 1920, p. 348); Beutler spells it *Crucha Camma*.

It is interesting to know that our present Buffalo River, C.P., was known in those early days as the *Kauka* (Hot. */gaob*, a buffalo; *!ab*, a river). This name was translated by the Dutch, Buffels Rivier, which later on became Buffalo River. Beutler describes it as: " Een groot lopend rivier de welke de Caffers Kauka ofte Buffels rivier noemden." There is a small river in the Prince Albert and Willowmore districts, a branch of the Traka river, which is mentioned in Plettenberg's " Dagverhaal " by the same name and as having the same meaning: " Verlieten wij de Traka s'morgens . . . passeerden . . . de Kauka of Buffels Rivier." Collins (Movdie, " The Record," p. 9, Part V) gives the Buffalo River of the East London district, the name Kognie, an attempt, apparently, to reproduce the name now used by the Kaffirs—" *Qonci*." It has been suggested that the Kaffirs

have assimilated the Hottentot *Kauka* (Buffalo River) to this word *Qonci* (Kaf. *um Qonci*, the Boerboon or Hottentot's Beantree, *Schotia speciosa*), but whether this is so or not is very doubtful and requires further investigation.

There is a small river eastward of the Buffalo River marked on Horne's Map, 1895: "The *Quenera R.*". The name is of interest because we can trace it step by step approximately to its original form. On Horne's Map (1895) we have it in the form "*Quenera*"; on Hall's Map of the Eastern Frontier, 1856, it appears in the form "Geneka"; in Arrowsmith's Map of the Cape of Good Hope, 184—, it assumes the form "*Kinigha* or Elands River"; and in Beutler's Journal, 1752, nearly a hundred years earlier, we have it in the form "Caninga ofte Elands Rivier," the Dutch name being a translation of the Hottentot name, the latter being derived from the two Hottentot words, !*Kani*, the Eland, *Taurotragus oryx; !ab*, a river. After passing the *Goenocbe* (Gonubie) River, Beutler mentions a small river that I have been unable to identify. He says: "Passeerde . . . de rivier *Goadar* beytekende Moeras rivier." *Goadar* may be from the Hottentot word *goa*, to be half dry. He next comes to "de *Goerecha* ofte Aloes rivier"; this would seem to be our *Kivelegha* (the Kaffirs having substituted, as they usually do, the *l* sound for the *r* sound, the latter being foreign to the Kaffir tongue), a river situated between the Gonubie and the Kei. This last-named river, the Kei, Beutler calls the "*Y Rivier*," ignoring the initial click altogether: "De revier Y die het land van de Caffers van dat der Tamboegis schijd," and on the same page he informs us that "de reviere Y beteijkende soo veel als Zand revier." In this, however, he would appear to have been mistaken, for the word *Kei* seems to be another form of the Hottentot *!ab*, a river, or the word *gei*, meaning great.

Another name of interest given by Beutler is *Tarka*, which is rendered "Women's river"—"Een rivier Tarka of het Vrouwenrivier genaamt." This is Beutler's spelling of the name of the river in the Prince Albert district, C.P.—the *Traka;* this name is derived from the Hottentot words *taras*, a woman, and *!ab*, a river. This appears to be the derivation also of the name *Tarka* as applied to the branch of the Great Fish River which has given its name to the Tarka district and to Tarkastad, C.P.

The *Leeuwen* river in the present Humansdorp district, C.P., is derived by translation from the Hottentot name of the river which Beutler gives as *Chammago*—"Quamen wij by de Leeuwenrivier, in het Hottentot Chammago gent." (Hot. *xami*; a lion). A small river is mentioned by Beutler as situated between the Leeuwen and the Kromme rivers (Humansdorp district, C.P.), the Hottentot name of which has now disappeared. He speaks of it as the "Ou Chamma, dat te erggen is Vetwater"; the name is derived from the Hottentot words *gou*, to be fat, and ||*gami*, water. This river is described by "baas Thuynier

Jan Hartogh " in the " Dagverhaal " of his journey among " de hier om heen legende Hottentots " in 1707, as " een droge rivier '*Oukamma*' in het Hottentots." Beutler also mentions " een droog riviertje Danka, soo veel beteijkende als Quaade rivier " (Hot. ǁ*hani*, hate; !*ab*. a river). This is a small branch of the Traka river, Prince Albert district, C.P.; and a small river which I have been unable to identify: " Een klijn riviertje Korouw ofte Klaauwen genaamt." This Hottentot name is derived from the word ǁ*Koras*, a claw, hoof; the reference of the name is lost.

There are six or seven other names of rivers given by Beutler of which he furnishes either the translation or supplies the current European name—it is not always quite clear which he intends us to understand. The names referred to do not appear, in the form given, to be of Hottentot origin. The presumption is that they are of Bushman origin. For example, he mentions a small branch of the Buffalo river which I have not been able to identify. He says: " Passeerden wij . . . de Meehouw of *Matjes rivier* die in de *riviere Kauka* uijtloopt." Others are: " *De rivier Gosacha* anders *Tijger rivier* "; " een grooter dito *Kohakoeka* ofte *Ezels rivier* genaamt "; " een rivier door de Bosjesmans Aga ofte Rietvelt genaamt "; " een groot rivier *Gomee* ofte *Baviaansrevier* genaamt "; the three last-mentioned rivers are mentioned also by Col. Collins: " The Record," Part V, pp. 48-49. The Gomee he describes as " a branch of the *Kyskamma* "; *Kookooha* as "the dry bed of a periodical stream"; and speaks of " the *Aha* rivulet," and " een kleijn loopend riviertje *Kavahe* of het Vrolijke rivier gent."

Plettenberg, 1778.

In the " Dagverhaal " of Governor Joachim van Plettenberg's journey the Hottentot place names are not so many, but they are of equal interest. The journey was undertaken a quarter of a century later than Beutler's, and here and there we get a hint that, even in that comparatively short space of time, changes had taken place in the local nomenclature, for we get together with the Hottentot name a Dutch one also, which is in a less number of cases a translation but a new name running sometimes concurrently with the older appellation which in some cases has quite disappeared from the map to-day.

The word *Karoo* has established itself as the descriptive name of a large area of South Africa—the word appears here with its meaning: " Wij vonden ons nu in het begin van 't Caro of Droogveld." The word appears to be derived from the Hottentot word /*Kuru*, to be dry, sparsely covered, arid; the Namaqua name for the *Karoo* is *Toró*. " De *Deepka of Brakke rivier* diebij natte jaar saisoenen breet en hoog scheen te moeten swellen " appears to be the present *Dwyka*, which is otherwise unmentioned, though it must have been crossed. Then we have " de *Gamka* of *Leeuwen Rivier* "; " de *Traka* of *Vrouwen Rivier*," a branch of the Olifants rivier, itself a branch of the Gamka

(Gamka is from Hot. *xami*, a lion, *!ab*, a river; *Traka* is from Hot. *taras*, a woman, *!ab*, a river); "de *Kauka* of Buffels Rivier," a small branch of the Traka, has been previously referred to. We read also of "de *Kariga*, ook de Buffels rivier genaamt"—here the Hottentot and the Dutch names are concurrent; the Hottentot name has, however, won through—this is a river of the Aberdeen district, C.P. The Hottentot name appears to be derived from the word *!aris*, the Steenbok—*Raphicerus campestris*—and the adjectival termination expressing abundance, *xa*. There is a branch of the Sundays river known as the *Vogel Rivier*, having its rise in the Tandjesberg, Graaff Reinet district, C.P. It is spoken of by Plettenberg as "de *Canniga* of *Vogel Rivier*"; the Dutch name translating the Hottentot. Wreede in his "Hottentotse Woordelijst" (Molsbergen, "Reizen in Zuid-Afrika," I, p. 222) gives the Hottentot word *K'annequa* as meaning "gevogelte," Lat. volucres; Kolbe gives it thus: Hot. *Kanniqua*, D. het Gevlengelde, L. volucres; while Valentijn gives us "*Kaoniqaa*, Vogels, in 't gemeen"; the Namaqua, as given by Krönlein, is *anixa*, abounding in birds. Pearston, Somerset East district, is on the banks of this river.

In my former paper (*S.A. Journal of Science*, XVII, p. 338, 1920) I mentioned the river of the George district, C.P., now named on the maps "the *Trekkentouw River*," and gave no less than fourteen different spellings of this name gathered from various authors. Plettenberg's "Dagverhaal" furnishes us with yet another; he gives it in the form "*Traka de Tkou* or *Vrouwe weg*." It would thus appear that my suggestion there as to the derivation of the name is confirmed: Hot. *taras*, a woman, *!ab*, a river, and *daob*, a way or path. Later in the "Dagverhaal" we have mentioned: "De Plaats van den oud Heemraad Jacobus Steijn, genaamt de *Tradauw*." Here we have the two Hottentot words, *taras*, a woman; *daob*, a poort, mountain pass; cf. also *Traka* and *Tarka*—Hot. *taras* a woman; and *!ab*, a river.

Our present *Gouph*, the name applied to the fertile Karoo district under the Nieuweveld range, C.P., is another place name that has assumed a variety of forms, as *Coup*, *Choup*, *Koub*, *Kaup*; Plettenberg gives it us in the form *Caups* (Hot. *gou*, to be fat; */houb*, the fat of the stomach). Then we have two other Hottentot names of rivers in the Knysna district, C.P., "de *Nounka of Swarte Rivier*" (Hot. *‡nu*, black; *!ab*, a river), a small river forming the western boundary of the district; and "de *Tsao* of *Witte Rivier*" (Hot. *tsaob*, ashes), which I have been unable to identify.

Alexander, 1838.

Starting from Capetown also, Alexander's Expedition was in a direction quite different from those of Beutler and Plettenberg; he made his way up the western side of the sub-continent, through Little Namaqualand and Great Namaqualand as far as Walvis Baai, and thence into the country of the Damaras, or

as they are now more generally called, the Hereros. His two volumes are of the greatest general interest, but the feature that appeals to the student of place names, and that makes his work exceptionally helpful, is that, distorted as his attempted reproduction of the Hottentot place names frequently is, he seldom fails to give the meaning of the name in English, which is a great help in the endeavour to discover the Hottentot words from which the names are derived. To attempt anything like an exhaustive review of these place names would require too much space. A selection from his pages of some of the names that were not discussed in the previous paper (*S.A. Journal of Science*, XVII, p. 334, 1920) will be given.

The general reader is, perhaps, better acquainted with those parts of the country through which Beutler and Plettenberg travelled than with that explored by Alexander. The south-east side of the sub-continent has invited occupation. Bushmen and Hottentots have practically disappeared before better organised peoples from the north and more civilised peoples from the south, and its story, as unfolded in its place names, is, on that account, of some popular interest. But Alexander's journey was through a part of the sub-continent, which, because of its forbidding character, attracted little attention except from the adventurous, and was comparatively little known, and the place names given by the Bushman and Hottentot occupants excited little, if any, interest except among students. That these are worth preserving, however, is now everywhere recognised, more particularly because we find in both Little and Great Namaqualand, even to-day, numerous names in their original form, uncorrupted by either European or Bantu distortions or accretions. Alexander did his best to preserve many of these place names by reproducing them as they sounded to his ear and by furnishing us with the meaning of most of them. As we have remarked before of aboriginal place names, they are generally descriptive, or they refer to the fauna or flora of the localities.

To mention a few of the descriptive names occurring in Alexander's work we have "the steep, rocky, and long pass of *Cardouw*" (I, 83), a pass in the Kamiesberg (Hot. ||*aro*, narrow; *daos*, a poort or pass). "The *Koanquip*, or 'running off' river" (I, 250), a branch of the Great Fish river (Hot. !*noë*, to be quick; !*ab*, river). "The *Koahap* (coming on) which flows from the *Gnutuas* (black morass), westward" (I, 235). Horne (Map) spells the former word "*Guaxab*," a branch of the Great Fish river (Hot. /*gu*, to come near; !*ab*, river); *Gnutuas*, the swamp in which the river has its rise, is from the Hot. ‡*nu*, black; ‡*goab*, mud. "The *Kei 'us*, or Great Fountain. This rises in a broad patch of high reeds at the commencement of the Kei Kaap or Great Flat" (I, 290). *Kei 'us* is from *gei*, great; /*ous*, a spring or fontein; and is situate on a small branch of the Great Fish river; Horne (Map) spells it *Gei-ous*. *Kei Kaap* was dealt with in the former paper. "There was a notch in the range called '*Isa Koodee taos*' (pretty girls' pass)" (I,

292) (Hot. *esa*, pretty; *khoiti*, women; *daos*, a pass or poort). This is a pass in the Hanami (Alexander's " *'Unuma* or Bulb Mountain ") range in central Namaqualand. " We reached the Arigha 'Oup (or Flowering Fish) river " (I, 294); a small branch of the Great Fish river; Krönlein spells the name ||*Harex'*-||*oub* (Hot. ||*harexa*, abounding in flowers; ||*oub*, a fish). The Flower-Fish river. " We reached *Aban'haus*, or Redbank, a part of the river so named from the red colour of the sandhills " (II, 71) (Hot. /*awa*, red; !*anib*, wall, bank). Hence arose the Hottentot name of the place now known as *Scheppmanns-dorf*, situate on the Kuisip, near Walvis Bay. On the " Times " Atlas it is marked " Scheppmansdorf (Rooibank)." " Mountains apparently two or three thousand feet high, and called the *Qua' nuas*, or clay-bank-trap mountains, that is, in which the foot is caught as in a trap," (II, 104). A range of mountains marked in Alexander's Map not far from the coast north of the Swakop river (Hot. ‡*goab*, mud; ||*noab*, a trap). " We passed . . . Hokap, or Spotted Mountain " (II, 113) (Hot. ‡*hou*, to be spotted; /*uib*, a mountain). A mountain marked on Alexander's map north of the Kuisip. Cf. Bonteberg. " We crossed the . . . Huerap or Crooked river " (II, 192) (Hot. !*hoa*, crooked; !*ab*, a river). Cf. *Kromme river*. " We offpacked . . . at the *Tuap* or Clay river " (II, 192) (Hot. ‡*goab*, mud); situate south of Rehoboth, Alexander's " Glenelg Bath." Cf. the *Qhaba* (the Modder river of the Orange Free State).

Besides these descriptive names, of which there are many others, Alexander furnishes not a few that refer to the fauna and flora of the country he explored. For example, " We reached a wooded hill (under cliffs) called *Neims* (giraffe ") (I, 229). (Hot. !*neib*, a giraffe). Situated on a branch of the Great Fish river, and spelt by Horne " *Naiams*." " A grotesque collection of rocks . . . called by our guides *Einhiras*, or the hill of the Laughing Hyena " (II, 112). (Hot. ‡*heizab*, the hyaena); placed north of the *Kuisip river* in Alexander's map. " We packed off in a hollow at *Keree Kama*, or Jackal's Water " (II, 119). Hot. /*geirab*, a jackal; ||*gami*, water. Situate on a branch of the Kuisip. " *'Nabagno* (or rhinoceros horn) to the north of us " (II, 122). Hot. *nawas*, a rhinoceros; ||*nab*, horn. North-west of Alexander's Tans mountains. " *Nahabip* or Tortoise Mountain " (II, 154). From !*nab*, a tortoise; /*uib*, a mountain. North-east of Rehoboth. " *Aantup*, or the Bird Stone Mountain " (II, 151). From *anib*, a bird; /*uib*, a mountain. North-west of Rehoboth. " We passed on our left *Tarahap*, or Quiver Mountain " (II, 113). Hot. ||*garab*, the Kokerboom, *Aloe dichotoma*, from hollowed sections of the branches of which the Bushmen made their quivers. Situate north of the Kuisip river. " We crossed the *Kubieb* or Stick-grass river " (II, 192). Hot. *Kawib*, steek-grass, *Aristida* sp. Marked south of Rehoboth. " The periodical river *Nukanip* (black bulb) " (I, 241). Hot. ‡*nu*, black; *ganis*, a sort of veld-kost. A branch of the Great Fish river, Great Namaqualand. " The *Kurusap* or Sour hill " (I, 255). Hot.

Kuru, sour; /*uib*, a mountain. Situate north of Bethany. "A place called *Hatep*, or Reed Water" (II, 203). Hot. ‡*ab*, a reed; !*ab*, a river. A place on the Great Fish river. "Eight miles E.S.E. along the Fish river brought us to *Kuis*, or Scent" (II, 204). Hot. !*huib*, the scent of the mimosa or of the giraffe. Near Hatep. "The *Quahanap* or Javelin river" (II, 336). Hot. *goab*, an assagai—a small branch of the *Koanquip* river marked south of Bethany.

KRÖNLEIN. "'Wortschatz der Khoi-Khoin." 1889.

Incidentally, this author furnishes a few Namaqualand Hottentot place names, together with their etymology: *e.g.*, !*Am*-‡*guis* (Hot. !am, green; ‡guis, the nose)—cf. "The watering place of Gnutneip, or Black Nose" (Alexander, II, 110). Hot. ‡*nu*, black; ‡*guis*, the nose; a small place on the Kuisip river. !*Am*-||*khus*. Hot. !*am*, green; ||*khub*, or ||*khus*, a thorn bush, the mimosa. !*Am-eib*. Hot. !*am*, green; *ei*, sight, view; places in Great Namaqualand and Damaraland. *Xamob* (Hot. *Xami*, a lion; !*ab*, a river). Alexander's "*Kamop* or Lion river" (I, 227). A branch of the Great Fish river. /*Gu*-/*aib* (Hot. /*gu*, dirty, rusty; /*aib*, firewood). A river between Bethanie and Berseba. ‡*Hoas* (Hot. ‡*hoa*, blue). A place south-east of Berseba. *Khaxa-tsus* (Hot. *khab*, war; *tsu*, to have trouble). The Hottentot name of Gibeon, Great Namaqualand: !*Uri*-!*nanib* (Hot. !*uri*, white; !*nanib*, the side of a house or mountain). A limestone range between Gibeon and Goa-mus: *Ouob* (Hot. *uo*, bitter; !*ab*, a river). A river in the Western Kalahari. /*Kan*-!*us* (Hot. /*kan*, the name of a succulent plant, *Salsola* sp.; !*us*, a claw). A place in the Warmbad area. Alexander: "Kanus, the place of the kan bush" (I, 206).

HORNE'S MAP. 1895.

This map is of considerable interest to the student of Hottentot place names because of the number of such names which are given in their pure Hottentot form; while so many others are so thinly disguised in their orthography that they are not difficult of recognition: for example, *Guibes* (Hot. *guib*, the Melkbosch, *Euphorbia mauritanica*, a place situate to the south-west of Bethany. !*Howeses* Mountain (Hot. !*hawa*, to turn back): A mountain range to the east of Bethany. Cf. Keerom. ‡*Has* Mountain (Hot. ‡*has*, broad, flat): A mountain range running parallel with the Koanquip river. *Nu* games (Hot. ‡*nu*, black; /*amis* or !*kamis*, both meaning ostrich): A place at the foot of the ‡*Has* range. Ganab (Hot. ||*ganab* the Kameeldoorn, *Acacia giraffae*): A place on a branch of the Koanquip river. *Goab river* (Hot. ‡*goab*, mud): A branch of the Great Fish river. Cf. *Qhaba*, the Modder River of the Orange Free State. *Gou-gouras* (Hot. *gou*, to be fat; !*gores*, a female zebra): A place in Great Namaqualand. *Ham-T'Aap*, or Lion River (Hot. *xami*, a lion; !*ab*, a river): A small branch of the Orange River. *Gobas* (Hot. /*gowes*, the wild fig): A place on the Guaxab river. *Tsawises* (Hot. *tsawib*, the black ebony tree, *Euclea*

pseudebenus): A place on the *!Kab* river, a branch of the Great Fish river (Hot. *!ab*, a river).

The place names thus culled from Alexander, Krönlein, and Horne are sufficient to show the general character of the appellations bestowed by the Namaqua Hottentots.

Miscellaneous.

Beutler mentions in his Journal "een ander revier, de Katte-revier, genaamt die in de Visch rivier uijloopt," but he does not give the Hottentot name of the river; this is, however, furnished us by Van Reenen ("Journal of a Journey from the Cape of Good Hope," 1792). He speaks (p. 21) of "the *Kat river* or Kaffer's or Hottentot's *Hunca* river" (Hot. */hoas*, a cat; *!ab*, a river). The European name appears to be a translation of the Hottentot. The frequency of these translated names would be, perhaps, a matter of surprise, but when we are informed, as we are by the Rev. Barnabas Shaw ("Memorials of South Africa," 1840, p. 37), that "many of the Dutch peasantry who reside in the frontier districts, and have been born in the country, speak it" (*i.e.*, the Hottentot language) "with fluency," the matter is fully explained, for though Shaw is speaking of the western part of this sub-continent, we can easily understand that the same condition of things would obtain on the south-eastern side also.

Baines ("Explorations in South-West Africa," 1864, p. 67) refers to "the *Quiep* or Elephant river." *Quiep* is an attempt, apparently, to reproduce the Hottentot *‡Koab*, an elephant. It is a river marked by Baines as havng its rise east of Windhoek. There is a pass in the Cedarberg range, Clanwilliamstown, C.P., known as the *Krakadouw Pass*—"the black cliffs of Krakadouw Heights, a massive peak" (*Cape Times*, 7/11/21); the name appears to be derived from the Hottentot words, *||Karaxa*, abounding in stones or pebbles; *daos*, a poort or pass. Cf. Kraggakamma, and D. Grúis pad, a drift on the Doorn river, Clanwilliam district, C.P.

Two maps of "The Eastern Frontier of the Cape Colony," the one accompanying King's "Campaigning in Kaffirland," 1855, the other being Hall's, published in the following year, furnish us with a few Hottentot place names, several of which have passed out of use, superseded by European names, while others have survived the changes of succeeding years—*e.g.*, on Hall's map we have the "*Kamka* or Yellowwood River," a branch of the Buffalo river, C.P. King gives it as "*Kameka* or Yellow-woods River." Another small branch of the Buffalo river appears on King's map as the "*Choka* or Thorn River." Kropf (Dict. in loc.) spells this name *Tshoxa*. King marks a branch of the Great Kei as the "*Tunxe* or Thomas River," while Hall makes the Thomas river to be a branch of the "*Tunxa*." King also has the *Kamega* and the *Genĕka* marked as branches of the Gonubie; these are names apparently Hottentot in their origin, but their meaning is not clear. King has the *Komga* river of Hall's map marked "*Gamka* or *Komga* River" (*Gamka*

would mean Lion River), a branch of the Great Kei, C.P. On King's map the *Kunap* is marked as a branch of the Great Fish river, C.P.; this name would appear to be derived from the Hottentot word *!ona*, crooked; or *!onap*, the crooked; there is also in Great Namaqualand a river mentioned by Alexander as the "*Konap* or Dry river," which appears to have another derivation. Then—a curious coincidence—there is a branch of the Great Fish river of the Cape Province marked the Kaap river, and there is a branch of the Great Fish river of Namaqualand, mentioned by Alexander (I, p. 220), of the same name: "the Kaap River, a branch of the Great Fish River." On Horne's map the name of this river appears in the forms *!Kab* (with the click) and *Kab* (without the click), indicating pretty clearly the origin of the Nama name, *!ab*, a river; which would appear to be the origin of the Cape Province name also.

The name *Inxu* as applied to a branch of the *Tsitsa river* in the Transkeian territories, known also as the Wildebeest river, is of interest because, as was pointed out by Kingon (*South African Journal of Science*, 1918, p. 718) the *x* click has been substituted for the *q* click, probably by someone unable, or not careful enough, to distinguish between the two, the correct spelling being *iNqu*, the name applied by the natives to the black wildebeest (*Connochaetes gnu*). But when it is asserted that *iNqu* is "the Hottentot name for the wildebeest" (p. 756), the statement is certainly open to criticism. The Nama Hottentot name for the wildebeest is *gaob*, while the Kora Hottentot name is *gaub*, or according to Burchell, *ghow;* this would suggest that the origin of the Xosa name *iNqu* must be sought from some other than a Hottentot source. The fact that Arbousset and Daumas ("Narrative of an Exploratory Tour," 1846) in their list of "Seroa or Bushman" words give the word *Gnu* in the very form in which it is used by European travellers and others, seems to put it beyond dispute that the word is of Bushman origin; and this is further corroborated by a Bushman prayer for food in which the word *'gnu* is used of this animal. The prayer is recorded by Arbousset and Daumas (*supra*, p. 256), and also by Stow ("Native Races of South Africa," 1905, pp. 133-134). This should appear to prove that the river name *Inxu*, or more correctly *Inqu*, is of Bushman rather than Hottentot origin.

This appears to be the fact of the case also with the Kaffir word *iQudu*, which appears in our place names in the form *Koodoo*—a siding on the Kimberley-Vryburg line; and *Koodoes Kop*—on the Touws river, C.P. The assumption (*S.A. Journal of Science*, 1918, p. 756) that *iQudu* is a Hottentot word does not appear to be capable of proof. It certainly is not a Bantu word, and does not appear to be used by other than Xosa-speaking people; but neither is it a Hottentot word. An early drawing of this animal, reproduced in Molsbergen ("Reizen in Zuid-Afrika," I, p. 32), gives the name as "*Coedoe*" "in het Namaquas Geib"; Krönlein ("Wortschatz der Khoi-Khoin," *in loc.*) has the word in the form "*Xaib*, subst. das *Kuddu*";

the Kora Hottentot name is given by Lichtenstein as *chaib*, and Burchell as *geip*. This means that we must seek elsewhere than in Bantu or Hottentot for the origin of the word *iQudu*. The only Bushman name for the animal that the writer has found up to the present is that given in Bleek and Lloyd ("Bushman Folk-Lore," 1911, p. 52), *!Xau*; but if, and how, *iQudu* has been evolved from this, or from some other Bushman dialectal form, remains to be discovered.

Bunbury ("Journal of a Residence at the Cape of Good Hope," 1848, p. 127) says: "We saw distinctly . . . the bold outline of the Winterhoek or *Kuruka* mountain. . . . The sailors call it the Cock's-comb mountain." Then on a map of the "Cape of Good Hope," by J. Arrowsmith (n.d.) this fine mountain is named "*Kuruka* or Winter Peak." This name *Kuruka* as applied to the mountain in the Uitenhage district, C.P., still known as the Cockscomb, I have met with nowhere else, and am puzzled as to its meaning. On "A Chart of the Bank of Lagullas, and Southern Coast of Africa," by J. Rennell, bearing the date "November, 1778," it is called "Craggy Mountain," a name repeated in Van de Sandt's "Companion to the Cape of Good Hope Almanac," 1847: "Craggy Mountain"—or the Cockscomb—or the Grenadier's Cap—or the Four Sisters, as it is variously termed, is situated . . . in the Winterhoek." The Hottentot name of this mountain is given on Hall's map (1856) as "*T. cummumqua* or Cockscomb." In the *Eastern Province Monthly Magazine*, II, 1857, p. 63, the Hottentot name appears in the form "*T'numqua*," and in the *Cape Monthly Magazine*, 1858, p. 367, in the more extended form "*T'mum cum qua*," both the latter forms receiving practically the same translation—"the Mountain of the Mist." This Hottentot name is derived from the words *!homi*, a mountain; and */nanuqua*, covered with mist. The name *Kuruka* looks more like the name of a river than of a mountain.

This paper might have been much longer, but its purpose will have been served if the attention of students is directed by it to this interesting branch of our South African topographical nomenclature.

A SELECTION OF ŠIṚONGA FOLKLORE.

COLLECTED BY

Rev. Herbert L. Bishop.

Read July 11, 1922.

A cycle of stories about Ṅwampfundla, The Hare, from the Maputụ country (South of Delagoa Bay).

Told by the late Samuel Mabika, in his youth a great warrior, a man of considerable importance in his tribe. With the smallest possible variation—everything in the tales cannot be translated—the stories are written down exactly as I heard them. It is, unfortunately, impossible to reproduce the vivacity, the interpretative gesture, the free use of "descriptive complements," and the very evident enjoyment of the stories shown by the narrator.

In his "Les Chants et les Contes des Baronga," and in his later work, "The Life of a South African Tribe," the Rev. H. A. Junod has given other forms of some of these stories, differing considerably in detail, and in the connection of the incidents, from the short series of tales as they were told to me. Perhaps a comparison of the different versions may be worth while, as helping to fix that typical form of the Hare stories characteristic of the BaṚonga, which he desiderates on p. 198 of the latter work as a first step in a careful comparative study of the stories throughout the Bantu field.

N.B.—The Hare is, in the stories, called "Ṅwampfundla." "Ṅwa," literally "son of," is often used as an equivalent of our "Mr." Ṅwampfundla may, therefore, be translated "Mr. Hare."

I.

Ṅwampfundla and the Lion.

Well, there was a lion with his family, his wife and four little lion cubs. And they were always hungry; so the lion, their father, used to go every day to hunt and to kill animals to feed his family. Now when he had killed a buck, he used just to eat the flesh, and throw all the other things away, because the lion thought, "Oh, I have no time to wash the things that are inside and to clean them so as to make them fit for eating." So the lion did every day.

Now one day, when the lions had just finished eating, the hare came and said to the lion, "Oh, lion, why do you throw all those things away; are they not good to eat?"

And the lion said, "Well my family are so busy; they are always busy. They like to eat and sleep. They do not want to wash those things and prepare them for eating. They say that it is not nice work for lions; but they do like to eat those things when they are made ready."

"Ah!" said the hare. "Well, I can do that work. I, the hare. If you will give me a little bit of it, I can make the food ready for your family."

"Oh!" said the lion, "that is good. I shall be glad to have somebody like you to do that work. I, myself, like that food, but I have no one to prepare it for me."

So the lion gave the food to the hare, and he went away a little distance to a pond, which was near that place, to wash the meat. As soon as he got into the path outside the lion's kraal, he found his grandmother standing by the way.

"Well, grandmother," said the hare, "are you here?"

The grandmother said, "Yes, my grandchild; I always stop in this place, as I am too old to walk any more. I always stay in the same place. I am hungry, for I cannot get anything to eat."

"Well," said the hare, "I have plenty of meat; plenty of flesh that my master, Mr. Lion, has killed. I am just going to wash this for him so that he may eat it."

Then the hare went to the pond and washed the meat, and when he came back he gave half of it to his grandmother.

But while the hare was going back to the lion's kraal he began to fear, and he thought, "The lion will be very angry with me, for I have only a little bit of the meat he gave me. I have given some of it to my grandmother. What shall I do? What can I do to deceive the lion?"

He stood in the path and thought. Then he went into the bush, and scratched himself against the thorns and the branches so that the blood came out over all his body, and then he went back to the lion's kraal with that little piece of the flesh.

When he came to the lion's kraal, the lion said, "Well, where is the meat? You took a lot of it, but there is only a little now. Where is the rest?"

The hare said: "Well, my master, at the pond where I went to wash the meat, there are many birds of prey, eagles and all kinds of birds of prey. As soon as they saw me with this flesh, they came and tried to take the flesh from me, and they scratched me all over like this. You see the blood is all over my body. They tried hard to take the flesh from me, and all that I could do was to lie down on the ground with this little piece of meat. They took away all the rest." The lion was deceived.

The next day, too, the same thing was done; but the lion began to think, and said to himself, "I must follow this Ñwampfundla, the hare, and see how those birds of prey take the flesh from him."

So he went just behind the hare when he went to the pond to wash the meat. When he came into the path he saw the hare's grandmother, and he thought, "Oh, the hare is always deceiving me, saying that the birds of prey take the flesh away from him. He gives it to his grandmother." Then the lion killed the hare's grandmother, and hung her body upon a piece of wood, while the hare was going to the pond. Then he went back again to his kraal.

Soon the hare came and found his grandmother. It seemed as if she was laughing, for her mouth was open, showing her teeth. He said, "Oh! grandmother, why are you laughing?" He did not know that his grandmother was dead, but when he came close to her he saw that she was dead. So he took her and buried her, and went back to the lion's place.

The lion said, "Oh, to-day you did not find those birds of prey, for you bring back all the meat."

The hare said, "No, I did not go to the place where I used to go. I found another little place, and I went there to wash the meat." But he knew in his mind that it was the lion that had killed his grandmother, and when he saw the lion the tears came into his eyes. He did not like the lion to know that he was crying for his grandmother, so he went to the side of the fire where the smoke was, and stood in the smoke.

Then the lion said, "Why do you stay in the smoke?" The hare said, "Oh, I just want to sit here." And the smoke came into his eyes, and the tears ran down his nose. He did this because he did not want the lion to know that he was crying for his grandmother.

One day after this, he came to the lion and said, "Well, Mr. Lion, my master, I saw a good place down there where there are a lot of monkey-nuts. If you will go with me I can show you a lot of monkey-nuts, so that you can have some."

Then the lion went with the hare to that piece of ground where the monkey-nuts were. They came there and the hare said, "Oh, let me make a heap of grass so that we may burn it and have the ashes to cook the monkey-nuts in. You can just sit here in the shade. I am your servant; I will do all the work and will bring you the monkey-nuts when they are ready for eating."

By and bye the hare said, "Now they have to stay there a long time till they are cooked." Then, when the lion was asleep in the shade, the hare went behind him and dug a hole in the ground just behind the lion, and in the hole he found a big root. So he took the lion's tail and tied it to the root with a piece of cord, and the lion did not know what was done. The hare filled up the hole again.

Then he went back and took just a handful of the monkey-nuts and gave them to the lion. The lion did not know what had been done to him, and said, "I like these monkey-nuts, bring them all here." But the hare said, "Oh, no; I just gave you those to let you taste them. You may as well come here and eat in this place."

"No," said the lion, "I don't want to." And the lion was angry. Then the hare said, "Well, I have nothing to do with you. If you do not want to come here, it's all right. I'll eat all the monkey-nuts."

Then the lion said, "I'll give you something. I will beat you if you don't bring the monkey-nuts here."

"You may do that if you like," said the hare, "but I won't bring you the monkey-nuts."

Then the lion tried to stand up to go to beat the hare, but his tail was fastened tight behind. He tried and tried, but he could not, he could not go. He tried to turn behind to pull the root up, but he could not reach it with his paw. He could not go from that place.

Then the hare said: "You have killed my grandmother and that is why I have done this to you." And he began to cry aloud and shout and call the people saying, "Come, come all of you, and look at this gentleman here, this great mhunumuzana!"

Many people came together, and the lion was killed, and the hare ran away after the lion was killed. That is the end.

II.

N̆wampfundla and the Leopard.

N̆wampfundla, the hare, was running away, running as fast as he could, so fast that his feet threw up the sand—pff! pff!—behind him. . . . As he was running away as fast as he could, he found a leopard in the path, who was carrying a piece of meat in her mouth.

The hare stopped and stood still in the path, looking at the leopard.

"Oh, Mrs. Leopard," said the hare, "what are you carrying that piece of flesh for? Why don't you eat it?" The leopard answered, "I am taking it home, so that I can feed my cubs."

"Oh!" replied the hare, "why should you do the work of looking after your cubs? You should be like a lady and let somebody do that work for you. You may just as well give me that work. Let me have charge of your cubs. I can keep them very well indeed. I have been a servant of the lion. I used to look after the lion's cubs. I can take care of your cubs for you. If you let me look after them they will get on so well that they will be as big as you are just in no time."

The leopard said, "Oh, I am very glad indeed to find someone like you to do this work for me. You can look after my cubs for me. Your words are good."

So the leopard gave the hare the piece of flesh to carry, and went and showed him the place where the cubs were lying asleep in a hollow tree.

"Oh!" said the hare, when he saw them, "this is not the best place to keep cubs in. You must take them out and go and put them in a good, comfortable place."

So the hare took those cubs out of the hollow tree and put them in a good place. Now the leopard used to give the hare some flesh for the cubs every day, and the hare took care of the cubs and fed them. The leopard used to hunt and to sleep. After a long time the leopard said to the hare, "Hare, I want to have a look at my cubs."

So the hare went with the leopard to the place where the cubs were, and took one and brought it and showed it to the leopard, and the leopard said, "Oh, you spoke the truth when you said that they would grow quickly. You keep them well. They are nice." There were four.

After the next day, the hare went and caught one of the cubs and killed it, and ate the flesh, keeping only one foot. By and bye, when he saw the leopard coming from hunting, the hare called the leopard and said, "Oh! my mistress, I told you that I would keep your cubs well. To-day I saw this, when I was taking them to walk outside. A young buck passed by in the bush and they saw it, and ran and caught it, and now they can get food for themselves. They caught a buck this morning and now they can kill their own food. I kept just one part of the buck this morning. Would you like to have it?"

"Yes," said the leopard; "yes, indeed. I should be pleased to have something that has been caught by my cubs." But she did not know that she would have part of one of her own cubs.

The hare took the meat and gave it to the leopard and the leopard ate it.

The next day the hare took another, and there were two left. He did the same the next day, giving a part of it to the mother, saying that it was part of a buck that the cubs had caught, and the mother was deceived all the time.

Then, when there was only one cub left, the leopard came and asked to see her cubs. So the hare said, "Certainly, but there is no need to go all the way to the place where the cubs are. I am your servant, and I will bring the cubs to you." So the leopard sat down in the shade of a big tree and the hare went off to fetch the cubs. But three had been eaten, and there was only one left. So he took that one that was left and brought it to the leopard, who took much pleasure in seeing it. Then the leopard said, "Where are the others, hare? Let me see them all."

"Yes," said the hare, "certainly you shall see them all; but I have taken such good care of them and they have grown

so big, as, indeed, I told you they would, that they are now so heavy that I can only carry one at a time."

"Good," said the leopard, "bring the others."

So the hare took back the cub that he had brought, as if he was going to fetch the others, but he had eaten them. So he brought back the same cub each time to the leopard, until the leopard thought that she had seen all her four children. "Thank you, hare," said the leopard, "you have kept my cubs very well."

But the next day the hare killed that cub also and then they were all finished. There were none left. Then the hare began to make a hole in the ground when the leopard had gone away to hunt, and while she was away hunting, the hare took the assegais of the leopard, and put them on the top of a burrow, and when the leopard came, she said, "You, hare, what are you doing with my assegais?"

"Oh!" said the hare "I'm not doing anything. I am just sitting here."

Then the leopard said, "Why didn't you come to meet me, to take the flesh for my cubs?"

"Oh!" said the hare, "I don't like to meet you.'

"Why not?" asked the leopard.

"Oh," replied the hare, "you had better feed your cubs yourself. I don't want to feed them any more."

"Well," said the leopard, "all right. Go and show me where my cubs are, and I will feed them if you don't want to."

"Ah!" said the hare, "you used to eat your cubs!"

"What!" said the leopard.

"Yes, every day you had part of a cub for breakfast, every day a paw of one of your cubs. What kind of flesh did you have every day?"

"If you don't go at once and show me where my cubs are I'll kill you," said the leopard.

"Oh," laughed the hare, "you will kill me, will you? Your cubs are all finished. They are all eaten. You have eaten them all. I did not eat alone. You had a piece of each of them."

"But you told me that they were young bucks," growled the leopard.

"Oh! no, no!" cried the hare. "Oh! no, no; not at all!"

Then the leopard was very angry, and she glared at the hare, and lashed her tail, and leaped at the hare, who threw one of the assegais at the leopard. Then the leopard took the assegai and tried to catch the hare, but the hare ran quickly inside the hole, and just when the leopard put her nose into the hole and tried to catch the hare, the hare came out of another hole near by and threw another assegai at the leopard. When the leopard rushed to that hole, the hare ran inside again with another assegai, and, coming out of the first hole, threw assegais at the leopard until she was dead. That is the end.

III.

Ṅwampfundla and the Buck.

After Mr. Hare had killed the leopard, he went away. Now as he was going down the path, he met a buck, who was walking slowly along, eating here and eating there.

"Good morning, Mr. Buck!" said he.

"Oh," said the buck, looking up and seeing the hare, "Good morning. What do you want with me? I don't know you."

"I want you to help me to make some gardens," said the hare. The buck agreed to this plan, and they went and found a good place and made some gardens, clearing the bush and grass away. When the ground was made ready, they planted some beans.

Now every day they used to go to the gardens, early in the morning to look at the gardens, and to see that the wild pigs and the other animals did not come to spoil them.

Soon the beans began to come up, the little green shoots piercing through the ground. But the buck was greedy, and he did not want to wait until the beans were properly grown; so he used to eat the beans while they were still growing, going back to the garden every night after the hare had gone to his kraal, and eating up the young leaves.

But the hare did not do this, for the hare was wise. He said, "No, I must wait until the beans are ripe, and then I shall have plenty."

But just when the beans were beginning to get ripe the buck came and stole in the night, and it was not long before the hare saw what was being done.

He said to himself: "Ah! there is somebody who comes to my garden and eats up my beans. I do not know who it is. I must keep watch. I must find out who eats my beans."

So the next time that he and the buck went to the gardens together, he showed the buck what had been done, and the buck said: "That is bad; some bad one comes and eats our beans. I see that that is true, but for myself I do not know who it is."

"Well," said the hare, "we must do something, or all our beans will be stolen. It is not the wild pigs, for I do not see their spoor. We had better come to-morrow and make a pit, and put some sharp stakes in it, so that the thief, when he comes in the night, may fall into the pit and get caught on the sharp points of the stakes. Can't you come and help me in this work?"

"Oh, yes!" said the buck. "It is a good plan. I shall be glad to help you, for I myself also want to have some beans." So they went away. Now the hare was very clever; he was the cleverest of all the beasts that are in the bush, so he did not wait for the buck to help him, but he went back to the garden that same night, and dug that pit, and put some sharp stakes in it. Then he went home and went to sleep.

Now in the night the buck said to himself: "The hare says we will make that pit to-morrow. I had better go to-night, before the pit is made, and have a good feed of those beans."

So he came from his kraal, walking quietly in the paths. It was very dark, and there was no moon, and all the stars were hidden behind the clouds, so in the dark he fell into the pit that the hare had already made. The sharp stakes went into his hind-quarters and the buck jumped out, leaving the mark of blood upon the stakes. Then he went home and lay down. The wounds hurt him very much.

Early next morning, while the sun was still low, the hare went to the garden, and saw what had happened there in the night.

"Oh!" said he, "somebody has been here. Look at that blood on the stakes, and look at that spoor in the sand. I have caught that buck who eats my beans!"

Then he took a piece of stick with the mark of blood on it, and he went to the kraal of the buck, and said to him, "Look at this! Somebody has been to my garden in the night, and has fallen into the pit that I made. Just look at the blood! I nearly caught him. I do not know how he got out of the pit again."

The buck said, "Oh, I do not know who it is."

Then the hare said, "What is the matter with you that you lie so stiff, and look so ill? You were quite well yesterday."

"Oh," said the buck, "I caught fever yesterday. I have caught a chill."

"Well," said the hare, "that's all right. It is a good thing that I came to see you, for I have some medicine that I can give you, if you like."

"Thank you, very much," answered the buck; "I shall be thankful if you will do so."

So the hare went and took a large piece of a broken waterpot and put some dry leaves in it, and poured some fresh water on them, and made a fire and put the pot on the fire.

Then he said to the buck, "Now this is the way to cure a cold. If we go into the steam and cover ourselves with blankets, we shall soon get well. I will have the medicine too, for I think I have caught a little cold also."

"Very well," replied the buck; "who will be first?"

"Oh, I will," said the hare. "I don't mind being the first. When I say 'Open!' you must open the blankets as quickly as you can, when I feel the heat of the medicine."

So the hare went in. Soon he called out, "Open for me!" and the buck opened the covering of the blankets, and the hare came out. Then the buck went in, and stayed for some minutes inside. Then he said, "Please open for me!" and the hare opened the blankets, and the buck came out.

As soon as the buck had come out, the hare took some pieces of wood and made a big fire, and said, "Well, I want to go in while this pot is boiling."

So he went in, and was covered by the blankets. Now as soon as the hare saw that the water wanted to boil, he cried out "Open!" and the buck let him come out.

He then put some more wood on the fire, and said, "Now, Mr. Buck, it's your turn again, come in."

"No," said the buck, "the pot will soon boil!"

"No, no!" cried the hare, "that is quite a mistake; there is plenty of time before the water boils; just come in for a little minute! I want you to get quite well!"

So the buck went in, and the hare covered him up. Then the water boiled, and the steam scalded the buck, and he was in great pain, because he was scalded by the steam, and he cried out in a loud voice, "Oh, Mr. Hare, open quickly for me; let me get out. I can't bear the heat here!"

"Oh, no!" said the hare. "You must pay me for my beans." And the buck died. He died there in that hot water. That is the end.

IV.

Ṅwampfundla and the Horn.

After the buck was dead, the hare skinned the buck, and took the large bone of one of the legs. He took this bone and made it hollow, and used it as a horn for blowing. He tried to blow with that horn, and it blew very well, so that people a long way off could hear the noise of the horn that the hare made out of the bone of the leg of the buck.

Then the hare went and found a piece of a calabash, and he took that piece of the calabash, and put some fat in it. He used it to keep some fat in. When he wanted the fat, he used to take it out of that piece of the calabash.

Then he went to the bank of the river, and he put the piece of calabash that had the fat in it down on the bank of the river, and he sat down on the grass beside the calabash. Then he began to blow the horn, making a noise "Ti-ti-ti" with that bone.

Now when he made that noise with the horn, all the animals in the bush heard the noise that he made; and as soon as he began to blow the horn, a great number of bucks that were in the bush heard the noise of the horn, and they said, "Ho! what is this? Somebody is blowing a horn; there is a dance somewhere! Let us go and see where is this dance at the kraal of the horn-blower."

So the bucks went and came to the place on the bank of the river where the hare was blowing the horn.

As soon as they came out of the bush, the hare tried to hide the horn, putting it in the grass where he was sitting, and he took up the calabash of fat from the ground, as if he had been washing himself, and was about to rub himself with the fat.

Then the bucks saw the hare sitting on the bank, and they came to him and said: "Shawan, good morning, Mr. Hare; where does this sound of the blowing of the horn come from?

this sound of dancing that we heard just now. We heard a lovely sound of dancing; where is the dancing?"

The hare said: "Oh! I can tell you that: it is just by the West. I heard the sound myself also; but I was washing, and I want to rub myself with this fat that you see here in this calabash."

"Thank you," said the bucks; "we will go to the West and see where is this dancing. We should very much like to be there." So they passed to that place.

Now as soon as the bucks were gone to look for the place of the dancing, the hare put away the calabash of fat and found his trumpet again, and began to blow it, making a loud noise, "Ti-ti-ti!" with the bone.

Then all kinds of animals came running to that place where the hare was blowing the trumpet, all kinds of animals, lions and elephants, and hippopotami, and leopards, and hares, and lizards, and all kinds of animals. They all came to the place where the hare was sitting blowing that trumpet. But as soon as the hare saw that the animals were coming out of the bush, he hid the bone in the grass, and took the calabash of fat, and pretended to rub himself with the fat.

Then the animals came to him and said: "Good morning, Mr. Hare, can you tell us where is that dancing? We have heard a great noise of a trumpet and we want to know where is the dancing, for we want to go there."

"Oh, yes," said the hare, "I can tell you; it is just over there on the West. I have heard that noise of the trumpet, and I myself am going to that dancing. I have just been getting ready to go. You see that I am rubbing myself with this fat so as to look nice when I go to that dancing."

"Thank you," said the animals; and they went away to look for the place where the dancing was to be.

Then there came a kwahle, an iguana, walking slowly, slowly, and not making any noise. She walked in the grass behind the hare. She was trying to find out where was the noise of the trumpet.

When he thought that all the animals had gone, the hare put down the calabash of fat, and took out the bone again and began to blow, making a noise, "Ti-ti-ti!" But as soon as he began to blow, the iguana came quietly, quietly, in the grass, and snatched the bone from the mouth of the hare, and went quickly inside the river.

"Oh!" shouted the hare, "give me back my horn!" He jumped up, and began to dance about on the bank, he was so angry But the iguana looked out of the water and laughed at him.

"You silly thing," said she; "you just play with the big people. You try to make fools of them, telling them to go to the West to a big dancing, while all the time there is no dancing at all; but it is only you sitting there blowing a horn. You are wicked; I will throw this horn away!"

Then the iguana swam across the river to a big stone, and came out of the water on to the top of the stone, and sat down, and began to try to blow the trumpet. But she could not blow it. She only made a little noise, "Pff! pff!"

"He wene!" shouted the hare. "You fellow, don't put your mouth on my bone!"

The iguana was all this time trying to blow the horn, but she could not. She only made a little noise, "Pff! pff!"

Then the hare went round to where the iguana was, swimming in the water, and came out on the other side of the river.

Then the hare came back to that side, chasing the iguana. Then the hare said to himself, "What plan can I make to get back my horn again? I can't find this iguana; it always goes inside the water, and I can't swim underneath the water."

So the hare went away and got some birdlime, and went to the place where the iguana used to sit and warm herself in the sun. He spread the birdlime all over that place, and when he had done so, he went to the side of the river where the iguana was, and tried to take the horn from her.

Then the iguana dived into the water, and came out on the other side, to the place where she used to sit to warm herself in the sun. Then she came out of the water and sat down on the top of the birdlime that the hare had put there. The hare stayed where he was on the other side of the river, drying his coat in the sun, and waiting till the birdlime could have time to catch the iguana.

He shouted across the water: "Just you give me that bone of mine!" The iguana said, "Oh! no, I won't. You want to get my bone and play tricks on the big animals, on the chiefs and gentlemen!"

The hare said, "I think that I will soon find that bone of mine. Wait a bit. I think that I will soon find it."

"No you won't," said the iguana.

"You wait a bit," said Ṅwampfundla. "You wait a bit. You will soon see I will find it!"

The hare was only waiting for the sun to dry the iguana's feet, so that the birdlime could stick. By and bye the feet were dry, and the birdlime got hold of the feet of the iguana, and then the hare went round to where the iguana was. When the hare came to the iguana it was stuck fast and could not move.

"Now," said the hare, "I told you that I would soon find my trumpet." And he took the bone from the iguana's hands, and went away. And as he was going away the iguana cried out after him, "Oh, Mr. Hare, can't you take me out of this birdlime?"

"What's that?" said the hare, stopping and turning round; "take you out of the birdlime? No, I can't. You are such a repulsive object that I can't even put my hands on you. I do

not want to touch dirty things like you. You had better stay there."

Then the iguana said, "I am not dirty; I wash myself every day."

"I can't help that," replied the hare, "you may wash yourself every day, but you are so dirty that I cannot touch you."

Now the iguana was crying all the time, and begging the hare to help her.

"No," said the hare, "I don't know what to do. My hands are so very clean. You had better stop where you are."

Then the hare went away into the bush, playing on the trumpet and making a great noise, "Ti-ti-ti." And he played the same tricks again. That is the end.

V.

Ṅwampfundla and the Elephant.

The lion is the chief of all the animals. He is the great chief of all the animals that are in the bush. He is chief even over the elephants, though they are bigger than he. There is no beast of them all that does not say, "Bayete, Hosi!" when they meet him in the path. Now, as everybody knows, it is not good for a chief, even a little chief, a hosana, to be alone. Every one of them has his indunas, and his servants. Is it not so?

Very well, the lion, who was the big chief of all the animals, had many servants. They were all servants of the lion, the chief of all the animals

Now Ṅwampfundla, the Hare, was the servant of the great chief, the lion. He went with him to all the places where he went. He did all things that his master, the lion, told him to do.

Now one day the lion said, "Let us go from this place. Let us pass through the lands to another place."

So all the animals who were the servants of the lion took their mats and the things that they wanted for the journey, and they went away from the kraal of the lion.

Now they went all walking together. There were many of them. The servants of the lion were very many, for he was a great chief. By and bye they came to a very fruitful country, and soon before dark they came to a place where there was a big *ṅwebe*, a nice fruit tree. It had plenty of good fruit on it. So the tinduna, the attendants of the lion, said to him, "O Hosi, Chief, here is a good place. Here is plenty of good fruit. Let us stop in this place. It is a good place for us to stop in. Let us pass the night here. We can sleep here very nicely." So their master the lion looked at the place, and when he saw the *ṅwebe* tree he

said, "Yes, your talk is good. We will stop in this place. You must leave that fruit for me. That will be for me to eat, but you, my servants, may eat anything else that is in this place, only leave the fruit of this tree for me."

So they all put down the things that they were carrying, and began to make ready to pass the night in that place.

Now just before it got dark, just when all the animals were getting ready to sleep, the hare went to the headmen and said, "I have been thinking about something."

"Yes," said they, "what is it, O Ṅwampfundla the hare?"

"Well," said the hare, "I am not quiet in my mind about that tree with the fruit, which our master the lion says must only be for him."

"Oh! what about that? Everybody knows the will of our master. What then?"

"Well," said the hare, "I do not want to get into any trouble. Suppose somebody gets up in the night and steals the fruit of the tree? Things like that do happen sometimes, you know. If such a thing should happen, I know that you would say, 'Oh, it is Ṅwampfundla the hare who has done this thing.'"

"Why should you think that?" said the tinḍuna.

"Well, there is something in my mind that says it," said the hare. "But I have a good plan. Do you see that old wooden mortar that they use for stamping corn? I will tell you what to do. You had better cover me with that old mortar, and then I shall be safe inside it, and if anything happens in the night everyone will know that it cannot be I, for I shall be shut up in the mortar."

"Very well," said the tinduna. They laughed at the hare, but they took the mortar, and turned it upside down, and covered the hare with it, so that he was quite shut up in the mortar. Then all the animals went to sleep, sleeping there in the bush, in the place where was the *ṅwebe* tree.

Now in the night, when all the animals were asleep, the hare lifted up the side of the mortar, and looked out. He did it very quietly. He looked out on this side, and the other side, and on every side, but everything was still, for all the animals were asleep.

Then, when he saw that all were asleep, he came out of the mortar very quietly, and he went to a place where they had left a basket, and he took the basket. Then he stood still to listen. He could hear the breathing of the animals as they slept, but none moved, they were all asleep, for they had eaten much of the fruits of the other trees that the lion had given them, and they were all asleep.

So the hare climbed up the tree quietly, going up a little bit, and listening, and then going up another little bit and listening again. But there was no movement among the beasts, they were all fast asleep.

Then the hare came to the branches where the fruit was, and he began to eat the fruit as fast as he could, eating all the fruit, and putting all the stones of the fruit into the basket that he had taken with him.

When he had eaten up all the fruit, the basket was full of stones. Then he came down quietly, and went among the animals, walking very softly, until he came to the place where the elephant was. The elephant was fast asleep. So the hare hung the stones of the fruit that he had eaten in a bag behind the ears of the elephant. (N.B.—A necessary variation here.) Then he went back again into the mortar, and covered himself up and went to sleep.

Now early in the morning all the animals awoke, and warmed themselves in the sun. By and bye they heard the hare scratching inside the mortar, crying, "Can't you please open for me? I want to see the sunshine."

They said, "Oh, we have forgotten about you." Then one of them lifted up the mortar, and the hare came out.

The hare came and stood before the lion and said, "Shawan, Hosi, good morning, my lord!" Then he looked up at the *ńwebe* tree, and cried out, "Oh......! I said last night that you must put me inside that mortar. Was it not true? Just look at that tree, the tree of our master the lion. Just look at it! Where is the fruit? It is all gone; someone has eaten it up! If I had not been shut up in the mortar all the night you would think that I had done it!"

Then all the animals looked up at the tree, and saw that all the fruit was eaten up, and they were very much afraid. And the lion was very angry, so angry that all the animals quaked.

The lion told all the animals to come together, and he tried to find out who had taken the fruit, but none of them could say who it was. The lion could not find out who had done it.

Then the hare came and stood just in front of the lion, and said, "Please, my master, may I speak?"

The lion said, "Speak!"

Then the hare said, "I will tell you a plan to find out the one who did this, eating the fruit of our master in the night."

"Oh," said the lion, "what is your plan?"

"I will tell you," said the hare; "but first tell the animals to help me, and to do what I tell them."

Then the lion ordered all the animals to do what the hare should tell them to do, so that the one might be found who had eaten the fruit of the tree.

So they dug a big, long pit. Now when the pit was finished, the hare said, "Now let everybody jump over this place here. If we all do so, we shall find out who took the fruit of the tree, eating the tree of our master."

"Very well," said the lion, "I myself, your master, will also jump." So the lion jumped first. Nothing happened.

Then the hare jumped, and nothing happened.

After that the leopard jumped. Nothing happened.

After him all the animals jumped, and still nothing happened.

At last the elephant was the only one left. The elephant jumped, and when he jumped the stones of the fruit of the tree fell down on the ground, falling from behind his ears.

Then the hare jumped up and said, " Look at this fellow! Look at the stones of the fruit that he has eaten! I told you we should find out who ate the tree."

The elephant said, " Myself, I do not know how these stones came here. I did not eat the fruit. How could I climb a tree to get the fruit? "

But the animals did not believe him. They all thought that he had eaten the tree of their chief the lion.

Then the hare said, " What a shame for a big fellow like you to steal the things of the chief! "

The lion said, " Kill him! "

So they caught the elephant and killed him, and gave the hare some of the flesh to carry to the chief's kraal. That is the end.

VI.

The Transformation of N̊wampfundla.

While the animals, servants of the great chief the lion, were going away from the place of the *n̊wcbe* tree, where the fruit of the lion had been stolen by the hare, and the elephant had been killed for the hare's fault, N̊wampfundla the hare was carrying a large piece of the elephant's flesh.

Now the hare, although he is very clever, is, as indeed you know, only a little animal. So as he was walking in the path, carrying the flesh of the elephant, that piece of flesh became too heavy for him. He was very tired, for the flesh was too heavy on his shoulders. And, also, he began to be very sorry in his heart because of the elephant who had been killed because of him, although he had not done any wrong. He was very sorry for the elephant that was dead. So as he walked behind the other animals, carrying the heavy piece of flesh, he was crying, saying, " They have killed my friend the elephant, but he did not eat the tree. He had no fault, the elephant my friend. They just killed him for nothing. It was I, N̊wampfundla the hare, who ate the tree of our master the lion."

Now the animals who were walking in front heard the hare crying and saying something, but they did not understand what he was saying, for they were far in front of him.

Then the lion stopped and cried out in a loud voice, " Hare, you hare, come near, and walk close to us, I do not want you to walk so far behind."

" Oh, my master," said the hare, " this piece of meat is too heavy for me. It is a very large piece, and I myself am not big. It is too heavy for me to carry. If I must carry it I cannot walk fast enough to keep near you. It is too heavy for me."

So the lion gave the large piece of flesh to one of the other animals to carry, and gave the hare a little piece that he could carry better.

But soon the hare was walking a long way behind the other animals again, crying and saying, " They have killed my friend the elephant. I weep for my friend the elephant. They have killed him, although he had no fault. He did not eat the tree of our master the lion. It was I, the hare, who ate the tree. The elephant had no fault."

Then the lion found that the hare was again walking a long way behind. He heard the hare talking, but he could not hear what he said, he was so far behind in the path.

So the lion again called to the hare, saying, " Come near, you hare, why do you walk so far behind in the path? Come close and walk near the other animals, my servants."

And the hare said, " Well, my master, I cannot walk as fast as the other animals, for this piece of meat is too heavy for me."

Then the chief gave him his assegais to carry, saying, " Hare, carry these assegais; they are not too heavy. Now you must walk with the other animals. I cannot have you walking behind us in the path. Go before me."

So the hare walked in the path in front of the lion. Now as he was walking in the path in front of the lion, he kept on singing the song that he had made about the elephant, saying, " Oh, they killed my friend the elephant, but he had done no wrong thing. They killed him, but he had not eaten the fruit of the tree of our chief. It was I, Ṅwampfundla the hare, who ate the tree of the chief."

Now the lion heard what the hare was singing, and he began to ask the hare about it.

" What! " said the lion, " was it you that ate my tree? "

" Yes, chief," said the hare. " I am very sorry because you have killed my poor friend the elephant, who had no fault at all. It was I myself, the hare, that ate your tree."

" Oh, is that so? " cried the lion. " Catch him, you people ! "

But when they tried to catch him, the hare ran away quickly. He ran away as fast as he could run, and all the animals ran after him, trying to catch him.

Soon the hare saw a hole in the ground, and ran into it, and the animals came to the hole, and they said to the lion, " Chief, the hare is here, in this hole in the ground. We saw him go into it."

"Oh," said the lion, "that's all right. We shall soon catch him now. Get him out of the hole."

So they went into the bush and cut a long stick, with a hook at the end of it, and they came back, and put the stick into the hole, so as to pull out the hare, who was in that hole.

They put in the stick, and as soon as they put it in, the hook caught hold of one of the hare's legs.

Then, when he saw that the hook had caught his leg, the hare laughed, and said to them, "Oh, you can do what you like. You will never catch me like this, you have caught hold of a root. Pull as much as you like, you are only pulling at a root." He just laughed at them, and said, "Pull, pull all of you, it is only a root."

Then they took out the stick, and put it in again, trying to get hold of the hare. This time the hook caught in a root inside the hole. Then, when he saw that the hook was fast round the root, the hare began to cry and weep, and ask for pardon. Then they thought that they had caught him, and the lion came to help them, and they all pulled with all their strength, all the animals, holding one another, until the hook at the end of the stick broke, and all the animals fell down on top of one another on their backs on the ground. Then the lion was very angry, and he told the hare all the things he would do to him when he caught him.

After that they cut another stick, a long one, and the same things were done again. They caught the foot of the hare, and he laughed at them. Then they thought, "We cannot have got hold of the hare for he cannot laugh when we catch him."

So they tried again. This time they caught a piece of root, and the hare cried out and wept, saying, "Oh, please pardon me! I will come out if you will only stop pulling. My leg will break. Please stop pulling. You are hurting me very much."

Then all the animals came to that piece of stick, and they all pulled as hard as they could, and the hook broke, and they all of them fell backward again on the ground.

Then the lion became exceedingly angry; his first anger was as nothing compared to this. He spoke, and all the animals trembled. But the hare in the hole only laughed at them, saying, "Do what you like, you cannot catch me. I, the hare, am greater than you all." He did this until they got tired of him.

Then the lion said, "We will leave this miserable hare in the hole. He went into the hole. Let him stop in it. Bring plenty of grass, and shut up the hole, so that he cannot get out. Let him be made fast in the hole. That will teach him to try to play with me."

So they took some grass, and shut up the hole, and went away. Now when they were gone, the hare tried to pull away the grass that was shutting the hole, but there was so much, and the animals had put it in so tight, that he could not. He was

shut in the hole. Now by and bye the hare began to be very hungry in that hole. He had nothing to eat. He became hungry and hungry and more hungry, until at last he ate one of his own ears. He was so hungry and he had nothing to eat.

But by and bye he began to be hungry again. He had nothing to eat, so this time he ate one of his legs. He was so hungry that he ate one of his legs.

Then he became very thirsty. His mouth and his throat were all hot and dry, and there was no water in that hole. There was nothing for him to drink. So he took one of his eyes, thinking that because the tears had come out of his eyes he would find some water in his eye to drink.

Then, when the hare had eaten his ear and his leg and his eye, there came a big storm of wind. And in this great storm of wind the grass was blown out of the mouth of the hole in which the hare was.

Soon Ňwampfundla could see outside. He came out, and looked around carefully, but there was nobody there. He could not see anybody. Then he went to a beehive that he found in a tree near by, and took some of the wax that was there, and made two little horns of that wax, and put them on his head, so that it appeared that he had two little horns growing on his head. Then he went to the place where the king lives.

Now when the king saw him, he called all the animals, and said to them, " Who is this strange person that comes here? "

Then they said, " Oh, chief, this seems to be that hare that went inside the hole and mocked you."

Then the hare said, " What, was that hare like me? I did not know that there was another hare like me. Was that hare lame in one foot? Was he blind in one eye? Was he without one ear? Had he two little horns growing on his head? "

Then the animals all said, " No, the hare that went into the hole was not like this one."

" No," said the hare, " I thought not. The fact is that I belong to a special tribe of hares. We are not like the ordinary hares that you see every day. We are a special kind of hare. We are all just like I am, with three legs and one ear and one eye. But know this all of you, that I am cleverer than any other hare. I know how to run faster with three feet than anyone that you ever saw; I can see farther than anyone else with one eye; I can hear better than anyone of you, with one ear. I can wait upon chiefs better than anyone else can."

Then the lion was pleased to see a hare like that. He had never seen a hare of that tribe of hares before. He was very pleased to see this new kind of hare that could do all these things with fewer legs and ears and eyes than other people. So the lion said, " Well, hare, you had better be my servant. If you can do all these things you had better do them for me. You can be my servant.' So the hare became the servant of the lion again. That is the end.

A SELECTION OF ŠIRONGA PROVERBS

BY

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INTRODUCTORY.

The ŠiRonga language, like other Bantu languages, is very rich in proverbs and proverbial expressions. Hitherto, these have been little studied. Mr. Junod, in his "Les Baronga," and in his "Life of a South African Tribe," has given a few examples. In the latter book he says, "Hundreds of such sayings might be collected." This is literally true; and although Mr. Junod appears to attach more importance to the Ronga riddles than to the proverbs, I venture to think that the latter are well worth studying, and collecting, for their own sake—and this for two reasons. They certainly throw light upon the working of the Native mind, and they present us with valuable material for the study of the language.

The proverbs which follow are a selection only from those which I have collected. Some I have heard in native conversation and noted down. Others have been collected for me by natives. Others have been found in native correspondence. Whatever their source, I have submitted them all to several competent natives, and have had their help in elucidating them. I am glad to acknowledge here my indebtedness to my native helpers, especially Messrs. J. T. Chembeni and T. D. Mabika.

If it is difficult, at the best of times, to define a proverb, it is perhaps still more difficult to decide just which ŠiRonga sayings should be grouped under that name. It is often difficult to decide between the riddle and the proverb, and between the proverb and what is merely a proverbial saying. Those which I propose to study now are all, I think, fairly to be classed as proverbs.

The ŠiRonga word for proverb is *Šiga* (c.p. Zulu is-Aga, defined by Bryant as a "current saying or proverb, which suggests a second meaning not literally that of the words"). This definition fits our ŠiRonga proverbs excellently.

One might have thought that, the great facts of life being the same everywhere, there would be frequent close parallels between ŠiRonga proverbs and those of European peoples. I have, however, found it very difficult to find such equivalents, at any rate in English, for more than a very few of the ŠiRonga proverbs. The same subjects crop up constantly, but the angle of vision is so different that often one can only link our proverbs to theirs by a loose paraphrase.

I had intended to group the proverbs according to similarity of subject, or attitude towards life, but found this well-nigh impossible. A rough classification under such heads as: Moral proverbs, general wisdom, warnings against danger or folly, etc., would be possible, but I doubt if it would be very valuable, at any rate with the material at my disposal. It will be noticed, however, that a decidedly cynical tone is heard in many of them, and that the rich man is regarded as fair game.

From the linguistic standpoint, a large collection should be very useful. The language of the proverbs is, as was to be expected, highly idiomatic, and frequently archaic. In the present state of the language, when old words are dying out rapidly, and when hard sounds are being softened, contact with forms that have a relatively high antiquity may help us to clear up doubtful points of more than one kind.

In the proverbs which follow, these phenomena are to be noticed among others: the use of shortened forms, especially of verbs (*yetla* for *yetlela*); suppression of the copula; irregular constructions; omission of conjunctions, common enough in ordinary speech, but very common in the proverbs; irregular pronominal concords; irregular noun formations (*ntiṛa*); and suppression of the nominal prefix (*šongani*).

This is, perhaps, sufficient introduction. Let us now consider the proverbs themselves.

A Selection of ŠiṚonga Proverbs.

1. *Nḍi ta tiṛa loko tihuku ti mili menyo!*

"I will work when chickens have grown teeth."
The phrase, *loko tihuku ti mili menyo*, is proverbially used in other connections, in the obvious sense of "never," in strong refusals. For instance, a boy working on the mines, refusing the solicitations of his friends to accompany them on their return to this country, will say: *Nḍi ta muka* (I will go home) *loko tihuku ti mili menyo*. After this, it is no use to expostulate.

2. *Amuhloti wa tinyaṛi ti ḅuya ha yene.*

"The hunter of buffaloes . . . they return with him!"
The danger of hunting buffalo is well known. The proverb recalls the unhappy experience of the famous "young lady of Riga, who went for a ride on a tiger." A warning against rashness could hardly be more forcibly expressed.

3. *Awa mafuṛa a nge ngi ba na likuma.*

"The man who has oiled himself never looks dull."
This is a representative of a class of proverbs, more or less cynical, which refer to the ability, and perhaps the habit, of the rich man, of looking after his own comfort and interests.

4. *Ntiṛa munḍuku i bulolo.*

"The worker (of) to-morrow is idleness."

It is idleness which says "I'll work to-morrow." A proverb which may go to show that, popular opinion notwithstanding, idleness is recognised for what it is, and is deprecated.

5. *Kinya u ta kolwa.*

"Help yourself greedily, and you will be surfeited." To take more than one's fair portion out of the common dish is, of course, very bad behaviour. We may, perhaps, compare "Enough is as good as a feast."

6. *Asinge ḍa ṅwinyi a ḍi hlekisi.*

"A master of a fool does not laugh at him."

This needs no comment.

7. *Ambyana i bitana hi likatla.*

"The dog is called by the shell."

When the dog hears the sound of the shell used to clean out the pot, it will run up at once. The proverb is used when rebuking children for "cupboard love," or older people for too often asking favours.

8. *Mamita tinyingi a dumba wa kwe nkolo*

"He who swallows fruit-stones trusts his throat."

This is used sarcastically of bumptious persons.

9. *Ambenga a wu ngi ganya ṅwana*

"The pot never gets (or gains) a child (or son)."

This proverb is, at first, not very obvious in meaning. It is explained to mean that, if one rears and supports the child of another man, the time will come when the child will leave its foster-father, and return to its own parents. Cherish it as one may, it will never be one's own.

10. *Leši ša buṛena a ši na ntehe.*

"A brave animal (*šihaṛi*) has no skin for carrying children."

To interpret: It takes so many assegai wounds to kill a brave animal, that the skin is so badly pierced as to be unfit for a woman to use to carry a child in, upon her back. The proverb is used of a man who does not take action that may lead to unpleasantness, for fear of the consequences, or, in other words, has not the courage of his convictions.

11. *Aliḍimi li dlaya ṅwinyi.*

"The tongue kills its owner."

Speech is silvern, but silence is golden.

12. *Akhombo a ba tingawuli.*

"Men do not evade misfortune."

Man is born to trouble.

13. *Akhombo ḍi ni šilanḍu.*

"Misfortune has an effect."

Sorrows never come singly. One sees, for instance, someone one does not like, and fears that something unpleasant will happen.

14. *Nhlampfi u nga ḍile; ma p̂si`na u ma bóna.*

"O fish, do not cry. The water is drying up even while you look upon it."

Had there been enough water, the fish might have made good its escape. As it is, regrets are useless. This is often said when one is trying to comfort someone who is in trouble. It is rather reminiscent of Kipling's butterfly beside the road, who preaches contentment to the toad beneath the harrow; and may perhaps be paraphrased as: "Make the best of a bad job."

15. *Ahuku a yi ngi hletela ŝitšuwana ŝa yimbeni.*

"One hen does not find food for another's chicks."

Charity begins at home. Look after Number One.

16. *Amusasi wa nanḍu hi ku pfumela.*

"A good man who has (is guilty of) a fault . . . it is to confess it."

The best thing is to confess a fault, or "Open confession is good for the soul."

17. *Abuhosi a byi tali; ku tala bulanḍa.*

"Wealth is not plentiful; but poverty is."

Or "Riches are never content, but poverty is," the meaning being that the rich man is never content with what he has, while the poor man has only too much of his poverty.

18. *Mayetla ndlwini munḍuku hi mayetla handle.*

"They who sleep in a house (to-day) sleep outside to-morrow."

A graphic reminder of the vicissitudes of life.

19. *Amati loko ma halakile a me he na ku woleliwa.*

"When water has been spilt, it can no longer be gathered up."

It is no use crying over spilt milk. This is interesting, as presenting one of the perhaps surprisingly few exact parallels with European proverbs.

20. *Andlopfu a yi ngi ɓindwa hi timhondo ta yone.*

"The elephant is never burdened with his tusks."

This is explained to mean that one should never complain about the troubles or heavy, disagreeable things of life One has to put up with them, to bear them.

21. *U hlawula nyawa, ku sala hobe.*

"You choose a bean; a grain of mealies is left."

This is not very clear, but I am told that the meaning is: "You favour your own people, and do not listen to the rest," and that it is used when reprobating a partial or unfair decision.

22. *Lwe wa nomo a nga na ku lubela mbangu*

"A liar cannot ask for a place to live in."

There is no place for a liar. A native moving from one part of the country to another must visit the chief of the district where he wishes to settle, and ask his permission to do so. This is *ku luba*. The Relative form *lubela* is required, because of a following word denoting place.

23. *U ṛuka muweti na we he tlhelweni.*

An alternative form is:

U ṛuketela muweti na byaṭhu byé he tlhelweni.

"You curse the boatman while you (or the boat) are (is) at the side (of the stream)."

You say what you like, when you think that you are safe, or, You are brave, as long as there is no danger. Out in the stream, with its swift current, the little keel-less dug-out canoe is none too safe a craft, and it is as well to be on friendly terms with the paddler when your safety depends upon his skill, and you are at his mercy.

24. *U nyela noto na afa wa ha ṛandiwa.*

"You are fouling your own nest."

25. *Angwenya a še nge wonḍa.*

"The crocodile will never be thin."

A big man, or rich man, has always got a way of doing what he wishes to. The crocodile has struck the imagination of the natives, and this is not the only saying in which it stands for lawless power.

26. *Awa ša kwe a nge ngi ɓiheliwa hi ntšhumu.*

"A man who has possessions is not harmed by anything."

A rich man has always a way of protecting himself. Compare the last proverb.

27. *Hleka wene, munduku ši ta buya ha wene!*

"Laugh! It will be your turn to-morrow!"

An obviously fit remark to make when endeavouring to comfort anyone in trouble.

28. *Anhonga ya masa' nthaku aku babisa.*

"The second stroke hurts (more than the first)."

This is less obvious. The meaning is that, if you injure anyone, he is sure to find a way to injure you more than you have injured him. The proverb refers to a capacity for bearing grudges, and for seeking vengeance, that is, perhaps, not confined to this people.

29. *Ma yala ku byelwa: a bona hi ku tlwaka ka ngati.*

"They refuse to be told: a man sees by the dropping of blood."

People refuse to listen to warnings of danger, but the danger is brought home to them when blood flows. Seeing is believing. *Experientia docet.*

30 *Ankolo a wu (ši) na burombe.*

"The throat has no pity."

As long as a thing is good to eat, one does not care how one gets it. This might be quoted in defence of vegetarianism; but the proverb is used in trying to comfort people who do not want to eat, because of grief. Bodily needs have to be thought of and satisfied; they assert themselves without reference to our sensibilities.

31. *Atihlo da ndlopfu wa wupfuta.*

"You are taking something out of an elephant's eye" (presumably without the elephant's permission). This is said to restrain someone from doing something rash, or from meddling with things which do not concern him, where such interference will be resented.

32. *Alitiho liñwe a li ngi nusa hobe.*

"One finger can never pick up a grain of mealies."

This is said to a man, or of a man, who diffuses his energies in different directions, has "too many irons in the fire," and so is unable to accomplish that which he has undertaken. He has only one finger to spare for this particular action, and therefore fails in it.

33. *U ta hanta šanga ba ku timbi litiho.*

"You will say many things at random, as if they had tied your finger."

I have heard that the "tying of the finger" is an expression used for what might be called torture of the Third Degree, persistent questioning of the accused with the

object of extracting a confession. "*Hanta*" means to say many things at random, or misleadingly, when one is forced to give evidence against one's will, and seeks to avoid disclosing what one knows.

34. *Ntsimbani ša ku nangu.*

"Stop them! They are tasting (food)."

This saying suggests several interesting points. *Ntsimbani* is equivalent to *tsimbani*, imperative of *ku tsimba*, to hinder, and illustrates the, apparently, optional nazalization which one sometimes finds with verbal and other roots. *Ša* replaces the expected pronoun *ba*, (c.p. similar substitution of *ši* for *wu* in No. 30). *Ku ku nangu* is a descriptive complement, expressing the action of tasting with the tongue, rolling on the tongue, savouring a flavour. This exclamatory phrase is used when people see others eating, and have no hope of being invited to share the feast.

35. *A wondi lakakuba ka ku sa ndepfana yiṅwe.*

"He got so thin that there was only one hair left in his beard."

The Rev. H. A. Junod (Les Baronga, p. 261) gives this as the reply, or second line, of an enigma, one of a class in which there is no real similarity between the objects compared, but only similarity of sound. His example is:

Hi kumi nkhuhlu, wu wupfa-wupfa, ka ku sala huhlu yiṅwe.

Hi kumi mulungu, a wonda-wonda, ka ku sala ndepfu yiṅwe.

"We found an nkhuhlu tree, which ripened and ripened; there only remained one *huhlu* (fruit) on it."

"We found a white man who got thinner and thinner, (until) there was only one hair left in his beard."

I took it, perhaps wrongly, as a proverbial expression of exaggeration.

36. *Šongani! fulara nthaku maginya.*

"He looks handsome in front; but he is ugly behind."

Cp. "*I šongani wa nhunu.*" He is good looking. *Maginya* means "ugliness." This is said of a man of prepossessing appearance, but who has a way of doing nasty things, and may perhaps mean "Fine feathers do not make fine birds."

37. *Anhonga ya kule a yi na ku lwela mhunu.*

"A stick that is far away cannot protect a man."

An absent friend cannot help.

38. *Aku tšhuta ku bitana ku nya.*

This is too gross for translation. It is an exact equivalent of "Coming events cast their shadows before."

39. *U thamisela nhlobo na u nge na ntheko.*

"You are waiting at the spring, but have no cup."
A common proverb used to rebuke unpreparedness.

40. *Amhunu o (a ku) khuša awa kwe ntlhubana.*

"A man polishes his own spear."
In other words, A man looks after his own family. Cp. No. 15, "Charity begins at home"; or "Take care of Number One."

41. *Loko fa nga di nge tlhari mbolekiwa inha ndi huli timhangu.*

"If it had not been a borrowed spear, I would have made danger (injured somebody)."

This is used of empty threats. "If it had not been for so-and-so, I would have given you a hiding."

42. *Añwinyi wa nkosi a byebula kubiri.*

"He who presides at the mourning shaves twice."

Cutting the hair is a sign of mourning. All who are in mourning cut off, or shave, their hair, but the chief mourner does this twice. The proverb is used when giving someone a second cup of beer when there is not enough to go all round again.

43. *Alibangu lo šira ñwinyi.*

"This spit takes the heat of the fire from its owner."

When men sit together roasting meat, each must put his spit on his side of the fire. It is used to emphazise the necessity of bearing one's own troubles

44. *Ansenge i dlawa hi ñwana.*

"A banana-tree is killed by its own fruit."
A child's transgressions hurt its parents.

45. *U dlaya nthuti* (or: *U nga dle nthuti*) *u wonga hi dolobeti.*

"You are destroying shade (or, Do not destroy shade), you are betrayed by the dull weather."

It is folly to cut down a shady tree because the sky happens to be overcast to-day. The time will come when you will long for the shade you have needlessly destroyed.

46. *Amhunu a nkhensiwa loko a file.*

"A man is praised when he is dead."
You must not praise a man in his lifetime, or you will make him proud.

47. *U fuka ntehe na u nga si bona ñwana*

"You prepare a skin in which to carry your child before you see the child."

This is taboo. This proverb is the Ronga version of: "You are counting your chickens before they are hatched."

48. *Aku (ba) hleka u (ba) hona ni ngoya.*

"You are laughing (so much that) you are spoiling your coiffure (carefully and laboriously made with red ochre)."

Said of people who are laughing immoderately, or at nothing.

49. *U kumi nkuwa wa ku yentšeka wo kha u yimile.*

"You have found a fig-tree that is easy to deal with; you can pick its fruit standing."

This is not possible. All minkuwa in bearing are too tall for that. Used generally in dismissing an importunate beggar, or a client who presumes on one's kindness.

50. *Eŝa bunanḍi a ŝi ngi tala nkombe.*

"Sweet things never fill the spoon."

You can never have enough of a good thing.

51. *Anṭhibà wukulu a wa nge pfumala mphinyi.*

"A large *nthiba* tree (iron-wood tree) does not lack a handle."

If you need a handle for your hoe, you can be sure of being able to find what you want on a large iron-wood tree. Cp. No. 3. Another hit at the rich man, who goes short of nothing.

52. *Nḍa nyenya nṭhumbula bisi.*

"I dislike raw manioc."

Said when checking someone who goes rambling on and on, with little or no reference to the point under discussion.

53. *Tingana ti ni bahlaleli.*

"Shame has watchmen."

This is said when people see a man doing something bad without shame, and are ashamed of him.

54. *Ku ḍibala nhlayi.*

"The speaker forgets."

A garrulous man may say all sorts of bad things, but they are remembered, perhaps to his hurt, by those who hear them.

55. *Ampfuṭhu i gubi nṭanḍa.*

"The tortoise has struck a piece of wood."

(1) *Ku guba* means to come to a stop, be unable to go further. This is a secondary meaning, derived from (2) To strike against something, be brought to a stand. So the meaning of the proverb may be illustrated thus: "*A hi ṭikeni timhaka leti. Ampfuṭhu i gubi nṭanḍa.*" "Let us leave this matter: we can get no further with it, or we cannot see any way out of it."

56. *Fambani, hi sa hi yimbula ngwenya.*

"Go away: we will stop and dig up the crocodile."

This is generally used when dismissing a number of people who have been with you, in order to be able to discuss something privately.

57. *U nga hene mpfundla u mila timhondo.*

"You must not allow the hare to grow horns."

Do not give people what is not fit for them. Said to people who are about to do this. For instance, if a child asks for a knife, and someone is about to give it, you stop the intending giver with this proverb. If you once give it, it may become a habit. (Hence use of *hena*, which also means "to be accustomed to"). Cp. No. 1.

58. *Alikaṛi ba jula ni le matini.*

"They look for a razor (even) in water."

Cp.

Ambuti ba jula ni le henhla.

"They look for a goat (even) above (ground)."

Used, for instance, when a thing is lost. You look for it even in unlikely places. Or of one who uses means in which he has not much faith, hoping to succeed.

59. *U holobela nsati wa milebe na u nge na bukosi.*

"You are quarrelling with a beautiful wife, while you have not got anything to pay her lobolo with."

I have had to paraphrase this. There is an allusion to a custom that cannot be explained here. The proverb is used in reproving someone who quarrels with a benefactor in whose debt he is.

60. *Ašilwa buṛena ša hluli ntsikeni.*

"That which fights with courage has conquered in the beginning." (Sc. and ever since.)

That which fights with courage is Death. *Ntsikeni* I translate "in the beginning." It is a noun formed from the verb *tsika*, to be the first to do something, invent. The proverb is used in comforting a man who fears death. "Do not fear. Death conquered even the first men. All men must die." (N.B.—The Ṛonga Eve and Adam are Nsilambowa (she who grinds herbs) and Lidahumba (he who eats snails); in the north, they are Gwambe and Dzabana.)

61. *U tekisa wa ku nfò-ò-ò, ŝanga u yimba nanga ya Ṛonge.*

"You keep on saying *nfò-ò-ò*, as if you were blowing a trumpet of Ronge."

Ku ku nfò-ò-ò is a descriptive complement, describing the sound made by air passing through a hole. *Ṛonge* (the

word seems to have no connection with Ronga) is the name of an old collection of songs accompanying dances, which were peculiar to the clans of the coast, and were performed after harvest, when the storehouses were full. They are fast disappearing. (See Junod, Life of a S.A. Tribe, p. 181 fg, Vol. 2.) I understand that the proverb is used when asking a rambling speaker to come to the point.

62. *Ananga ya hosi a yi ngi yala ku fuma.*

"The chief's trumpet never refuses to command."

The chief's words are always orders. He must always be obeyed.

63. *Ankwahla wa tikululi hi ku hupa.*

"The quail set himself free by flapping its wings."

The trapped bird does not tamely submit to capture. It struggles to get free. So the proverb is quoted to encourage anyone in difficulty or danger. "Never give in!" "Never say die!"

64. *Nyama suka ni makhala*

"The meat goes away with the coals."

If you cook meat on a fire without fat, it will be spoilt, because it will stick to the coals. It will be useless. So a man who feels himself disregarded or despised will say: "*Ndi nyama suka ni makhala!*" meaning, "I am not thought anything of, I am despised."

65. *N̊wankanga-marambu i šo ka ni nhlube.*

"A skeleton has no flesh." (Lit.: a piece of boneless meat).

You do not go for meat to a skeleton, and you do not go for money to a poor man. You can't wring blood out of a stone.

66. *I timhondo ta humba; ta ku huma noňweni.*

"They are snail's horns, they come out of the mouth."

This is used of a boastful coward; his strength is only in his mouth.

67. *Ašikhumba ba songa ša ha tanile.*

"They roll up a skin while it is still damp."

A new skin can only be properly rolled up while damp. This is used when about to start on a journey or walk. Men have eaten, and are ready for the road. If they wait about and talk, they will want to eat again, and will lose time, so one will say, "*A hi fambeni, ašikhumba ba songa ša ha tanile.*" "Let us go, they roll up a skin while it is still damp."

68. *Aku lelela ku banga buyeni.*

"To bid farewell causes people to be strangers." Lit.: "makes strangeness."

If one is parting from someone who lives quite near to him, and whom he will see again the same day, one does not give the usual good-bye, "*Hambani!*" but this proverb takes its place.

69. *Abuhosi i nkila wa buti.*

"Power (or Wealth) is the tail of a water-rat."

If you try to catch a water-rat by the tail, the skin of the tail is detached by the rat's struggles, and remains in your hand, while the rat itself escapes. The proverb is said of a chief who is removed from power, or a rich man who loses his wealth.

70. *Ampfula u nkhensa i ku neliki.*

"You praise the rain which has rained upon you."

Used in explanation of one's constantly praising someone who has helped one.

71. *U nyiketela ankoṛo u pšha timbale.*

"You offer me (because you despise me) to something dangerous, and will burn me with spots."

Nkoro is a bird like a toucan, feeble of flight, and so despised. Here it stands for something despised. *Timbale* are painful spots on the flesh caused by continual exposure to the heat of a fire. The proverb is used, for instance, by a man who has been purposely given bad advice, or led into trouble by another.

72. *U pfukeḷi ampfungwi.*

"You got up, facing the back of the hut." One usually gets up facing the door.

The proverb is used in speaking to someone who is disagreeable. It is the exact equivalent of our "You got out of bed on the wrong side."

73. *U ni nkhilo wa sanga, u ṭika ṅwana, u hakaṛa nuna.*

"You have the trick of the "*sanga*" crab; you leave your child, and carry your husband on your back."

The female of the "*sanga*" crab is sometimes seen carrying the male on its back. Used by a husband to his wife if she insists on doing what he does not want her to do.

74. *U hlekelela šanga nḍi ku rwaleli nyama?*

"Are you smiling at me as if I had brought you meat?"

Said by a man who has something against another, and, going to him, is received with smiles, as if nothing had happened.

75. *U na šisaka mu?*

"What custom have you?"

Suppose that a man has done something, and tries to hide it. You ask him this question, implying that this is not the first time that this has occurred. It is understood to be a strong phrase, and will be resented.

76. *Hi kumani ka muṛi a yaka yindlo.*

"He finds a tree and makes a house (of it)."

Used of a man who has no fixed abode, whom one never knows where to find. The tree stands for any place he lives in for a short time.

77. *Atuba ḍi kukulukela ansatini.*

"The dove coos to its mate."

Quite idyllic, but, alas! only apparently so. This is said to someone who is always troubling you, telling you to do this or that. We may paraphrase: "You are not my wife (or husband); you have no right to talk to me like this!"

78. *U šabeli ku yambala.*

"You bought it to wear." Cp. "You have made your own bed and must lie on it."

Said to someone who is oppressed by trouble of his own making.

79. *Atihabu ti hlekana makoba.*

"The monkeys laugh at each other's thin stomachs." (and do not see their own). Fat monkeys are not to be found.

The pot calls the kettle black.

80. *Amukoṅwana i nyonga ya ndlopfu.*

"A relative by marriage is an elephant's hip."

This alludes to the feeling of restraint, or exaggerated respect almost amounting to fear, felt by BaRonga for their relatives by marriage. Someone is killing a goat to feast such a relative who has called at the kraal. He is asked why he is doing so, and replies, "*Hi ta ku yi? amukoṅwana i nyonga ya ndlopfu,*" *i.e.*, is very big, an important person.

81. *Šikhongolotana ša nsinḍisa.*

The centipede of trouble.

You may throw a centipede away, but it keeps on coming back, so if people keep on making trouble, you call them "centipedes of trouble," or "troublesome centipedes."

82. *Anhlampfi hi ya manhingeno.*

"The fish (that you catch) is (as you hope) the first of many."

Often used when a first child has died and is being mourned. "*U hlupekile, ŇwaManyana, anhlampfi hi ya manhingeno.*" "You are sad, So-and-so, the fish is the first of many." As natives think that if a first child dies, other children born to the same parents will either die, or be sickly, the phrase implies, "As the first child is dead, we do not think that you will have others, and if you do, they will probably die too." Rather cold comfort!

83. *Ku pšalana mahlu.*

"Eye's fellowship."

Used of false friends, who are friends in appearance only. "*ŇwaManyana i ku pšalana mahlu.*" "So-and-so is a false friend."

84. *U tšha mati, u tiyela ntaka.*

"You fear water; and go to the mud."

Water here represents the chief, who has power to clear up difficult questions. Mud represents people who may be more approachable, but who cannot help in the matter.

85. *Nsola hosi a sola a sukile.*

"He who insults a chief does it when he has gone away (from the chief's kraal).

Comment is needless.

86. *Ţunya rumba.*

"Pierce the abscess."

Used of irrelevant talk. "Come to the point."

87. *Timba libya.*

"Tie the girdle."

Used of restraining one's desires, in order to attain some object that is specially desired. "Take up a hole in your belt so as to hold out till you can be satisfied."

88. *Dana u fihlula* Or *Aku da u ba u fihlula.*

"Eat and break your fast."

Used in such connections as this: "*A nga tiri hi ku nga pimisi; a da a fihlula.* "He does not act without thought. He looks before he leaps."

89. *Amhisi i tlakuli tšuri.*

"The hyæna has taken away the mortar."

Said when there is severe famine. The hyæna is perhaps the most loathed of all the animals, and stands for famine. The mortar is that in which corn is pounded. It is useless in time of famine.

90. *Añwana wa makwabu i nḍelekana wa masimu.*

"A brother's son is the border of the fields."

Just as all the gardens near the kraal might appear to belong to it, were it not for the borders marking off those of one proprietor from those of another, just so a brother's son is seen, sooner or later, not to be one's own. Cp. No. 9.

91. *Abudangwana ku da mbilu.*

"The heart eats (even) bran."

When one is remonstrated with for doing what is apparently useless or foolish, he may reply with this proverb, "I do it because I want to." A man may be led by his desires to do what others think useless or silly.

92. *U nga tibele mutwa ṭolweni!*

"Do not thrust a thorn into your knee."
"Do not bring trouble on yourself."

93. *Šikohlela miyela, ku da bambe ba hona.*

"Be quiet, phlegm, other people are eating and spoiling (food)."

Said by people who are eating, to someone who coughs to call their attention to his presence, hoping to be asked to join them, and whom they know is not in need of food, and whom they do not wish to receive. Used to check greediness. "Go away, you have had your food, leave us to eat ours. You think we are spoiling food. Go away!"

94. *Šilema a ši kohli ẕengu.*

"A forgetful man does not forget a plan" (when it serves his turn).

Šilema is properly a lame man, but it is also used of a forgetful person.

THE "DESCRIPTIVE COMPLEMENT" IN THE ŠIṚONGA LANGUAGE COMPARED WITH THAT IN SESOTHO AND IN ZULU.

BY

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Read July 13, 1922.

I.—GENERAL STATEMENT

The ŠiṚonga language is that of the natives of the southern extremity of the Province of Moçambique, who are called BaṚonga by themselves, and Landim by the Portuguese. It exhibits the usual characteristics of the Bantu family of languages, to which it belongs. Not the least interesting of its grammatical features is the class of words for which I now propose the name "Descriptive Complement."

These words present us with a most curious grammatical problem, that of determining their true nature, and of classifying them as parts of speech. Bearing in mind the difference in standpoint taken by European and African minds which is shown by other phenomena of Bantu speech, it will be well to try, in the following discussion, to divest ourselves, as far as possible, of European grammatical prepossessions, and to leave until the end of our study any consideration of the many names which have been proposed and used to describe this class of words by various writers on the Bantu languages. My use of the term "Descriptive Complement" is not in the least intended to beg the question.

The presence of these, or similar words, has been noted in several Bantu languages, and careful study will, quite possibly, show them to exist in all the languages of that group. It is interesting to note that they are recorded also in Ewé, a language of the Sudanian family.

They express, as a rule, at any rate, sudden impressions, and may, it seems, be coined almost at will. The Rev. H. A. Junod, in his "Life of a South African Tribe," vol. 2, p. 147, gives an instance of such coinage which came under his own observation. Such coinages, one would imagine, would have, in the majority of cases, a short and precarious existence; but the descriptive complements in common use and widely known in ŠiṚonga form quite a large class of words, a class probably far larger than we are at present able to judge from our very incomplete lists. The meaning, at any rate, in the case of new coinages, is greatly helped by the use of gesture and intonation. This is, I think, true of them all.

These words are invariable, and either imitate or express actions, sounds, movements, states, position, colour, taste and smell. An examination of my ŠiṚonga list, together with one of about 360 in SeSotho, and a very incomplete list of about 140 in Zulu, shows that the main types of ideas expressed by these words are, apart from the mere imitation of sounds, suddenness and rapidity of movement, completeness or intensity of movement or action, transience and brevity of action or movement, degree to which the action is performed, unexpectedness, the doing of an action to a small extent, or by many people, and such actions as falling (especially into water), striking, breaking, smashing, and rushing.

It will thus be seen that these words are far from being merely onomatopoetic, as some have regarded them; indeed, my lists show that true onomatopoeias are comparatively few, and that a very wide range of impressions is conveyed by them.

II.—*The Descriptive Complement in ŠiṚonga.*

In ŠiṚonga, the descriptive complements occur with the verbs *ku ku*, *ku li*, and *ku ti*

These verbs, beside their use as auxiliaries, have two meanings:—

1. *To say* (in fugitive speech).
   e.g. *li* (Present) *U li yini?* What dost thou say?
   ti (Past) *U ti yini?* What didst thou say?
   ku (Historic) *A ku ku mine.* He said to me.
2. *To do, i.e.*, to make a sound, etc.; like the vernacular "go" and "went." "He went like that" (He acted in that way), *e.g.*, *Tihuku ti li kwee*," "Chickens go" (say) "*kwee*" (Cp. Junod, Grammaire et Manuel de Conversation Ronga, p. 151).

It is in this sense (2) that we constantly find *li*, *ku* and *ti* used with the descriptive complements.

I now give a classified list of some descriptive complements in ŠiṚonga, classed according to syllabication, verbs used with them, and the impressions they convey. I give also, sect. III, a list of polysyllabic words used, apparently, with the copula *i* (is). I am not sure that these last are to be described as descriptive complements. They may possibly be of the nature of nouns or adjectives, although they do not resemble them grammatically.

A.—Classified List of Descriptive Complements (ŠiṚonga).

This list is not, of course, to be considered as more than a small selection of the descriptive complements in ŠiṚonga

I.—*Monosyllabic.*

(*a*) Used with *ku ku*.

1. *Denoting colour.*

(Double vowels so written to express prolonged vowels.)

dzuu, e.g., ku ku dzuu, to be red, especially of the sun at morning or evening.
nkwa (*a* strongly nasal), ku ku nkwa, to be yellow.
mphaa, ku ku mphaa. To be pure white. Cp. *baa* (used with *li*).

2. *Denoting sound.*

bo, ku ku bo. Expresses noise of breaking.
ŝu, ku ku ŝu, sound used to scare birds.
ṭwee, ku ku ṭwee, noise of falling, to fall.
nṭwin, ku ku nṭwin. Sound of a blow.
(Final *n* in a few cases written to nazalize vowel before it.)

3. *Denoting actions.*

gaa, ku ku gaa, to fall flat backwards.
ge, ku ku ge, to eat.
ihn, *hin* } ku ku hin, to do thus—so—.
nḍwin, ku ku nḍwin, to turn round rapidly.
ṛa, ku ku ṛa, to wither, fade, be dry.
tlhwa, ku ku tlhwa, to shine at a distance.
tlee, ku ku tlee, to draw up soldiers ready for battle.

(4) *Denoting states.*

ntši, ku ku ntši, to be dark (lacking light).
ḇi, ku ku ḇi, to be destroyed, annihilated, disappear.
dzi, ku ku dzi, to stand or be upright.
ḍaa, ku ku ḍaa, to be scabby .
ḍu, ku ku ḍu, to be heavy, deep, *e.g.*, Burongo byi ku ḍu, The slumber is deep.
ntse, *mpse* } ku ku ntse, to be silent.
nṭhu, ku ku nṭhu, to be quiet.
šwee, ku ku šwee, to be transparent, pure (of liquors, cp. baa, with *li*).

Real onomatopoeias included in the above may be: *bo, su, ṭwee, nṭwin.*

(*b*) Used with *ku li.*

(1). *Denoting colour.*

baa, e.g., Ma li baa (sc. maṛibye, stones). (The stones) are pure white.

(2) *Denoting sound.*

kwee, sound of chickens chirping, *e.g.*, Tihuku ti li kwee. Chickens chirp.

(3) *Denoting actions.*

go, to look glum; *e.g.*, Abhanu ba li go. The men look glum.

gaa, to fall flat on the back, cp. *ga* with *ku*.

I have no example of a monosyllabic descriptive complement with *ku li* denoting a state. Real onomatopoeias in the class are represented by *kwee*.

(*c*) Used with *ku ti*.

I have no example denoting either sound, colour, or action.

Denoting state.

mphu, *e.g.*, *ku ti mphu*, to be dark (lack light).

I know no onomatopoeia in this class.

II.—*Disyllables and Polysyllables.*

It should be noted that some are formed by reduplicating disyllables.

(*a*) With *ku ku*.

(1) *Denoting sound.*

nkwanka, ku ku nkwanka, to be yellow. Cp. nkwa. I, (a) 1, above.

(2) *Denoting sound.*

ntunti, *e.g.*, ši ku ntunti. Sound of a blow.

tlhuku, ši ku tlhuku. Sound of a blow, or gallop of a horse.

pfotlo. Ba ku pfotlo, sound of eating.

dokodoko, *dokodoko*, } ku ku dokodoko. To chirp (sparrows).

(3) *Denoting actions.*

tlhuku, *E ku tlhuku*. He gets up suddenly.

tayitayi, *e.g.*, Ši ku tayitayi. It struggles (when caught).

sulusulu, *Ši ku sulusulu*. It floats in water.

sikisiki, *E ku sikisiki*. He shakes.

pulupulu. Yi ku pulupulu. It (a dog) wags its tail (in satisfaction).

phatiphati. Ši ku phatiphati. It scintillates.

ňwoňoňwoňo. Ba ku ňwoňoňwoňo. They murmur.

fohlo. Ba ku fohlo. They sit on the ground in a ring.

gobodolo. Ba ku gobodolo. They sit down sad.

hatihati. Ši ku hatihati. It shines.

hingi. Ku ku hingi. To pass quickly before one.

humelelo. E ku humelelo. He appears suddenly.

ketiketi. Ši ku ketiketi. It scintillates.

loto. A ku loto. He gobbles up.

ndašu, *ndašu*. } A ku ndasu. He falls heavily.

yaluyalu. Ši ku yaluyalu. (Of food.) It moves about quickly in boiling water.

nangu. Ba ku nangu. They are savouring the flavour.

(4) *Denoting states.*

dlunyu }
dlunya, } E or A ku dlunyu. He is naked.

kutlu. Ba ku kutlu. They are destroyed. They get up suddenly.

ntentenene. Ba ku ntentenene. They are in the open, *i.e.*, are clearly visible.

pŝhululu. Ba ku pŝhululu. They are straight, free, without trouble.

tikòò. Ku ku tikòò, *e.g.*, Ba miyelile ku ku tikòò. They were silent and quiet.

tititi. Si ku tititi. It is fresh, cool.

tšowee. E ku tšowee. He is quiet.

wololoko }
woloko. } E ku woloko. He stands upright, is in an upright position.

Real *onomatopoeias* included in the above class seem to be: *dokodoko, ḍokoḍoko, pfotlo, tlhuku* (sound of blow or gallop), *ṅwoṅoṅwoṅo.*

I have no examples of disyllables or polysyllables with *ku li* or *ku ti.*

III.—*Polysyllables with the Copula.*

In these, reduplication, or partial reduplication, is to be noticed. It is uncertain under what part of speech they are to be classed. Being used with the copula, they would seem to be either nouns or adjectives. Their general likeness to those descriptive complements mentioned in Section II. (a) 3), above, has led me to mention them here. I have already pointed out that they do not present the characteristics of nouns or adjectives.

Examples are:

lewulewu. Leŝi i lewulewu. These things balance, see-saw.

lisekiseke Idea of flopping down.

lošološo. Manyana I lošološo. So-and-so walks dispiritedly

yaṛiyaṛi. Idea of jumping about confusedly (of movements of a crowd of people)

I have, so far, not noted any parallels with these, in either SeSotho or Zulu.

B. It will now be helpful to compare the phenomena which we have found in ŠiṚonga, with what is found in SeSotho and Zulu. First of all, a study of my lists in these languages shows that the range of ideas expressed by the descriptive complements in all three languages is the same If a wider range seems to be covered by the descriptive complements in SeSotho than in SiṚonga, it is only because my SeSotho list is much more complete than my ŠiṚonga one. I have not been able to complete an examination of all the descriptive complements given by Bryant for Zulu, but do not doubt that, when that study is completed, it will indicate this conclusion for that language also

Secondly, it would seem strange that, although the ideas expressed are the same, and, as we shall see, the formation of the descriptive complements in all the three languages is similar, yet there seem to be no exact reproductions in one language of descriptive complements found in another of the languages compared.

In all three languages, real onomatopoeias seem to be, relatively, very few.

In the SeSotho list, monosyllables form less than 10 per cent. of the whole number. In the Zulu list, of 140 examples, the same proportion is found. In my short ŠiṚonga list above of about 70 examples, the proportion is much higher, reaching about 40 per cent.

In ŠiṚonga, the descriptive complements are used, as we have seen, with the verbs *ku ku*, *ku li*, *ku ti*. In SeSotho, they appear, with only 10 exceptions in my list, with the verb *ho re*, to emit a sound, to say, to do. Eight of my SeSotho examples are used with *ho etsa*, to do; and two with *ho ema*, to stand (*e.g.*, *re ema tsi*, we remain perplexed); *ho ema tsoe*, to be perpendicular.

In the Zulu list, as far as it goes, all are used with *uku ti*, of which Bryant (Dict. p. 108) says: "This verb is peculiar to the Zulu and other Bantu languages, and cannot be exactly compared with anything in English. Its uses are very extensive; but mostly it is used in connection with some *verbal particle*, often onomatopoetic. . . . The verb *ti* is conjugated in the regular manner, the particular particle being simply placed after it and standing independently."

The question whether or not some of these words, in all these languages, have rightly been described as adverbs, will be dealt with below.

As to formation of disyllabic and polysyllabic descriptive complements, the following may be here said.

All three languages afford examples of *reduplication*, *e.g.*, in ŠiṚonga: *Sikisiki* (shake), *phatiphati* (scintillate). In SeSotho: *eke-eke* (of water: become agitated); *fuku-fuku* (noise made by a stick thrown, and striking the ground. In Zulu: *beke beke* (undulate); *bada bada* (stagger about).

In ŠiṚonga, *humelelo* presents an instance of the formation of a descriptive complement by *change in the final vowel of a verb*, which is matched in Zulu by *cupuluzi*, idea of piercing; *cupuluza*, to poke with the finger.

SeSotho presents one peculiarity that does not appear in the other lists; that of the *combination* of two descriptive complements; *ho re thu-soalala*, to disperse in all directions.

The same language has other interesting reduplications, *e.g.*, *ho re morea-rea*, to hesitate, in which partial reduplication occurs; *popololo*, to diminish—a kind of double reduplication; an augmented reduplication in *nyenye-nyenyene*, to make a distant

noise; treble reduplication in *tatata*, to beat much, where the treble reduplication may serve to intensify, if that were possible, the meaning of the presumably more primitive *ho re ta*, to finish.

Several instances, in Zulu, of what may be abbreviation of a verb, or, as I think, more possibly more primitive forms than the verbs in question, will be noted below.

SeSotho shows multiplication of the last consonant of the word in *tsirrrri*, to run, and *tsorrri*, to be many, numerous.

In all three languages, instances occur of descriptive complements with prolonged final vowels:

In ŠiṘonga, *tikòò*, to be quiet; *gaa*, fall flat on the back.
SeSotho, *fuu*, to be quite drunk; *hoaa*, to be white.
Zulu: *bu*, ask something; *bi*, spin round.

SeSotho has instances of doublets, with differing final vowels; *chala*, pass quickly, and *chali*, pass very quickly; *chole*, go in quickly; and *choli*, go in quickly. Compare, in Zulu, *cite* and *citi*, both meaning to scatter. In Zulu, also, are examples of descriptive complements differing from a regular verb in an internal vowel only, *e.g.*, *bulukasha*, same meaning as verb *bulukusha*, to lay something down in a long mass. Note that another descriptive complement of the same meaning is *bulukushu*.

In ŠiṘonga, as we shall see later, it may be that descriptive complements have given rise to nouns, verbs, and other descriptive complements. The same is true of SeSotho. The question of the relation of many Zulu descriptive complements to verbs will come before us later.

For the moment we may close this comparison with the remark that while, in SeSotho, the descriptive complements have often two or more different meanings, in the other two languages this seems rarely to be the case.

IV.—*Are these words primitive or derivative?*

If one could accept the position of Endemann (SeSotho), who calls them interjections; of M. Junod, who says some may be interjections; and of Grout, who, in his Zulu Grammar, classes at least five of them as interjections, without, I think, recognizing them at all as a separate class of word, then we might well regard them as being primitive. Miss Werner, too, suggests the name "interjectional roots." The instance of the coinage of one of these words, and the formation of a verb from it by its coiner, mentioned by M. Junod, and alluded to above, would also point in this direction. Further, the fact that some, as will, I think, appear from the lists given above for ŠiṘonga, seem to be genuine onomatopoeias—as Bishop Colenso (in one place), the late Snr. Torre do Valle, Dr. Hetherwick, the late Mr. Stapleton, and Father Torrend have all thought was the case with some of those they have recorded, would seem to argue a primitive origin. On the other hand must be placed the widely-held opinon that they are "verbal particles" (Bryant), "fragments of verbs" (Colenso)

It may perhaps state the problem more clearly if we look at a few examples, in ŠiŖonga and Zulu.

In ŠiŖonga: *gobodolo*, to sit down sad, may come from *ku goba*, to frighten.

hingi, expressing the idea of someone passing quickly before one, may come from *hinga*, to lay something across something else. Cp. *bulukushu* and *bulukusha* in Zulu. So with *hingihingi*, to repeat the action expressed by *hingi*.

humelelo, expressing the idea of sudden appearance, if it be rightly regarded as a descriptive complement, must originate in the verb *ku humelela*, to appear.

nkwanka, to be yellow, may be a modified reduplicate of the descriptive complement *nkwa*, having the same sense.

In Zulu, take:

bamu, to wade, verb *bamuza*, to wade.
bengu, toss wildly about, and *bengula*, with same sense.
bobo, make a hole, and *boboka*, get a hole bored; *boboza*, make a hole. And very many more might be cited.

The impression made on my mind by a study of the lists is that it is far more likely that the descriptive complements are primitive than that they are worn-down verbs. It will, of course, be impossible to quote largely from the lists; that would swell this paper to impossible dimensions; but the following may be sufficient to support my contention.

In ŠiŖonga:

dzuu, idea of redness. Cp. *ku dzuka*, to be red, to blush.
nkwa, idea of yellowness. Cp. *nkwanka*, descriptive complement, conveying idea of yellowness.
ŝu, noise made in scaring birds. Cp. *Ku ŝukuta*, to scare birds.
tlee, to muster soldiers, Cp. *ku tlebisa*, same meaning.
dzi, upright position. Cp. *ku dzimeka*, to be upright.
šwee, idea of clarity, pellucidness. Cp. *šweta*, noun of ḍi-ma class, clearness, purity of water.

In SeSotho:

ho re phali, to lash with a whip. Cp. noun *sephali*, whip.
khi, to be dirty (of mouth). Cp. verb *ho khiba*, to have a dirty mouth.
tle, to stand amazed. Cp. *tle*, interjection of astonishment.
kaka, idea of meeting. Cp. *kakanana*, another descriptive complement, with apparently the reciprocal verbal ending *-anana*. To come together.
tjeke, throw. Cp. *tjekete*, descriptive complement meaning to throw over the shoulder.
psha, smash. Cp. verbs *pshatla*, to break in pieces; speak much; *pshatla*, to say, tell.

From Zulu, specimen examples have already been quoted of descriptive complements which may have given rise to verbs.

As far as my lists carry me, there is ground for believing that in both ŠiȐonga and SeSotho the descriptive complements have given rise to nouns, verbs and other descriptive complements, and in Zulu to verbs, at least.

V.—The way is now open for some discussion of the *name* that should be given to this class of words.

It will, I think, be agreed that it is highly desirable that Bantu grammarians should come to some agreement in the matter of terminology. There is matter for an article on that subject. One can only state the need here, and use the many conflicting terms in use for this class of words to point the moral

German writers call these words "sound-pictures" (Lautbilder), or "word-pictures" (Wortbilder). We may leave the former for the present. The latter seems to be too indefinite. Both, however, draw attention to the descriptive nature of these words.

Colenso, as stated above, in his First Steps in Zulu, says that some "are probably imitations of the sounds referred to," *i.e.*, *onomatopoeias*. With this the late Snr. Torre do Valle, in his Diccionarios Shironga-Portuguez e Portuguez-Shironga, agreed. It appears that only a comparatively small number of these words are really onomatopoeias. Further, this name only indicates origin, and not function.

The name "*onomatopoetic adverbials*," proposed by Dr. Hetherwick (Yao and Kinyassa), denotes their function, but too definitely, and also refers them all to onomatopoetic origin.

"*Onomatopoetic vocables*," proposed by the late Mr. Stapleton (Congo), refers them all to a common origin. The word "vocables" is too wide in meaning.

Torrend, as quoted by Mr. Junod, calls them "*onomatopoetic substantives*." We have seen that they have nothing in common with the noun, no prefixes, etc., and only some of them are onomatopoetic. The words cited above, Section III., used with the copula, have no prefixes.

Mr Junod, reviewing previous opinions (Life of a South African Tribe, Vol. II., p. 147), decides for the name "*descriptive adverbs*": which he had previously used in his Grammaire et Manuel de Conversation Ronga. He says that perhaps some may be interjections but that as most of them follow the verbs *ku ku, ku li, ku ti,* they are adverbs rather than interjections. He notes that their meaning is greatly assisted by gesture and intonation, and that, while some are primitive, others are derivative, *e.g.*, *humelelo*, the impression caused by someone who appears suddenly, comes from the verb *humelela*. Thus, some are derived from verbs, in his opinion. He goes on: "Some, placed between the verb *ku* and the adverb, have a real transitive nature, and can be preceded by a direct object, especially those which express actions. He illustrates: *A ku ši wuyuwuyu*, he throws that away. *A ku mu mpsi*, he makes him *mpsi*, he binds him; and gives an example of the use of the verbal reflexive prefix *ti* used in this

way: *A ku ti mpsi.* He binds himself. He goes on: "Some are at the same time transitive and intransitive, according to the sense. Ex. *A ku kwe-kwe*, he drags his leg. (Gait). *A ku yi kwe*, he drags it (the pole). I have not yet found these uses, as far as I have observed. The fact, shown I think above, that many of these words give birth to regular verbs, is, as he says, highly interesting.

Those used with *ho etsa* and *ho ema in SeSotho* seem to be *adverbs*. Note also these phrases (Dieterlen Dict.), *e.g.*, *ngoo. Liliba li omile ngoo.* The fountains are quite dry. *Ngoo*, be quite dry. *Ta: O ba bolaile ta.* He has killed them all. *Ta*, to finish. *Qeche*, to be extinguished suddenly. *Qeche a shoa.* He is already dead. *Too. Ho re too.* There is nothing. *Ke le mong too.* I am quite alone. *Tsekhe* (to break, of day). *Bosiu bo sa tsekhe.* The night finishes completely. It is daylight.

Now it seems to me to be difficult to follow Mr. Junod in calling these words adverbs, if they can have so much of the nature of verbs as to take a direct object. Perhaps, too, the derivation of verbs from adverbs is difficult. For these reasons I think that the term *adverb* must be rejected; but I think that the word "descriptive" should certainly be kept, as part of any name that may be agreed upon for these words.

Colenso, again, called them (op. cit. p. 128) "particles used adverbially," and Miss Werner, writing of those in Ewé (Lang. Fam. Af., p. 47) says, "they are functionally adverbs, since they qualify the action signified by a verb, but some may be classed as adjectives." Cp. adjectival use of *pšhululu*, in ŠiRonga." They are not by any means all particles, and while they certainly may be said to be used adverbially, the difficulty is to find a name, and not a description, which will express this. Grout and Endemann call them *interjections*. I agree with Mr. Junod that some of them may be such. Cp. *tle*, quoted above, in SeSotho. They are by no means all interjections.

The same objection lies against Miss Werner's proposal to call them "*interjectional roots*." In any case, are they all roots?

The late Snr. Torre do Valle, in the work quoted above, calls them *verbs*. He is alone in so doing.

They have also been called, I think by Colenso (op. cit.) "*fragments of verbs*." The Zulu examples given above show his data for this opinion. I do not think that a wider survey of the lists, even in Zulu, would have confirmed this.

On a review of the whole question, I propose the adoption of a term suggested to me by Miss E. W. Bishop, that of "*descriptive complements*." They are descriptive—highly so—and it may be said of them all that they are complements grammatically. A wide term is necessary, to include them all. If the word "complement" is held to be used in an unusual sense, I would point out that it covers more than one part of speech, and further, that we seem to have here a part of speech foreign to our European ideas and terms, and that no English term can be perfectly satisfactory, if used in its rigid European grammatical sense.

THE INTERVOCALIC "N" AND "L" IN OLD PORTUGUESE AND THE RISE OF PORTUGUESE NATIONALITY.

BY

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Read July 12, 1922.

Floreça, fale, cante, ouça-se e viva A portugueza lingua e já onde for Senhora vá onde for Senhora vá de si soberba e altiva.— ANTONIO FERREIRA (1527-69).

For a concise study of two philological laws typical of Old Portuguese, it is necessary to say a few words about the geographical aspect of the country where the people that gave birth to these phenomena live. As is well known, the changes which the Latin language underwent in the various parts of "Romania" are closely connected with historical and geographical problems.

Portugal and Spain constitute two clearly differentiated countries. This is clearly indicated in a variety of ways, including the geographical situation and aspect, the characteristics of the races, and unity of language in each country.

Among the many books that give definite evidence of the formal separation of the two countries, one, as far as the geography of the Peninsula is concerned, is of outstanding importance. This is the book of Elysée Reclus, entitled "Pourquoi le Portugal a pris cette forme d'un quadrilatêre irrégulier?" which clearly shows that the frontiers, far from being determined by political conventions or mediæval struggles, represent a physically logical separation of the two countries. With the exception of the passes of "Portela de Homem" and "Valle da Mula" and a few others, in some instances the summits of the mountains detain the passing clouds, which, transforming themselves into small rivulets, fertilise the lands of Portugal and leave barren many a vast Spanish region. In other instances, the rivers reaching the Portuguese frontier become more impetuous owing to the broken nature of the country, and run alongside the mountains in the new courses which these follow when marking the frontier.

We could speak also of Paul Choffat, Silva Telles and others who have devoted their attention to this subject of true scientific interest. However, this is not the object of our study.

Nothing is more difficult than to speak of the Portuguese race. Are we "meridionals"? Do we belong to that type of the *Homo mediterraneus*, dark-complexioned, lively, intelligent, artistic, adventurous and warlike? We do not believe so.

In pre-historic ages, we have suffered various Nordic invasions, not to mention the Celts. Later on, the coastal parts and the banks of rivers, known as the richest regions, were in the hands of the Phœnicians, Greeks and Carthaginians. The Romans conquered them. The influence of the barbarians, with the exception of the Wisegoths, who inhabited the country during a long period, did not leave any impress upon us. When the Arabs were compelled to abandon the north of the Peninsula, they settled for some time in the south, where a good many ethnical traces have been left by them.

Our first kings peopled many parts of the country with Normans, a race which already existed in the north, being remnants of the incursions of the pirates attacking the French and the English coasts. They used to come as far as the Peninsula, and, attracted by the beautiful climate, most of them remained.

Diego Barnardes, a writer of the sixteenth century, truly said that "our land had the magic wand which made people forget their homes, their fatherlands, far away . . ."

Connections of a commercial character and conquests in other parts of the world brought new blood to our race. After all, that quadrilateral to which Reclus refers is no more than a great crucible from which there rises a choice racial product, with its own characteristics, although it may present physically that great variety of aspects and that complete scale which ranges from the purest golden to the Berber type darkened by the African sun.

Political unity is the natural result of the two factors: territory and race. Language ought naturally to accompany this evolution by creating philological laws altogether different from those of the other Romance languages.

When the Portuguese nationality was constituted, a formidable linguistic work was being performed in the whole Romance world in connection with the formation and separation from each other of the Neo-Latin languages and dialects. We can count several of them in the Peninsula:—The Portuguese, the Castilian, the Catalonian, etc. There are prehistoric traces of the Portuguese language,* in documents belonging to the period before the twelfth century, when the first writings in Portuguese appeared. As an instance we may mention the "Testamentos

* Words from the Portuguese lexicon with a Latin-like termination frequently used in documents written in Barbaric Latin of about the 12th century.

do Lorvão," as also the "Livro dos Foraes Velhos. . . ." The Portuguese language appeared in writing for the first time in the twelfth century in the form of a poem attributed to our second king.

Attention may now be directed to two very important laws of Portuguese philology, dating from the twelfth century, which laws are a phenomenon almost unknown in other Romance languages, and which denote another step towards our linguistic separation and towards the most complete definition of our nationality.

One of them is that *the letter N between vowels disappears and nasalizes the previous vowel.* This law is clearly established by documents written in old Portuguese.*

Later on, the nasalization disappears, but the original orthography is maintained for a long time and only gets obliterated in modern Portuguese. It is to be observed that in Spanish—I call the Castilian language Spanish—the said phenomenon is not to be found, and the language follows the general law of the Romance languages by preserving the letter N between vowels.

Examples:

Lat. tenit	>Port. tene>têe>tem	Span. tiene
Lat. fine	>Port. fie>fi>fim	Span. fine
Lat. bonum	>Port. bonu>bôo=bom	Span. bueno
Lat. lunam	>Port. luna>lua>lua	Span. luna
Lat. arenam	>Port. arêa>areia	Span. arena
Lat. cenam	>Port. cena>cea>cêa>ceia	Span. cena
Lat. minutum	>Port. minuto>miudo>miudo	Span. menudo

It might be stated that there are many words in Portuguese which have not undergone this modification, but it is to be remembered that those, which are found in such cases, have appeared in the language used in modern times and are of learned origin.

This goes to prove, therefore, that the Portuguese language followed the destinies of our nationality, creating thereby different laws from those which govern the evolution of Spanish phonetics, exactly in the same period in which the principles of our nationality were being assured. The exact date at which this transformation started operating is about the twelfth century, coinciding, therefore, with the constitution of the Portuguese kingdom. Seven centuries after the fall of the Roman Empire, the Latin language had been transformed into a number of languages, but Portuguese marked its strong originality, avoiding.

* We call "old Portuguese" the Portuguese language in use before the 15th century.

as it does, the Latin form in consequence of the law to which we have just referred.

There is also another or second law of the same era, especially characteristic of the Portuguese language: *The letter L in the middle of the word disappears* while it remains unchanged in nearly all the Romance languages, except in a few cases.

In the Roumanian, Genovese and French Provençal languages, it is changed into R; and sometimes in the Provençal language it is turned into U; in Portuguese it disappears altogether, as already stated.

Examples:

Lat. filum	>Port. fiu>fio	Span. hilo
Lat. solum	>Port. solu>sóo=só	Span. solo
Lat. dolet	>Port. dole>doe	Span. duelo

What we wish to impress upon the reader is that we had next to us as our neighbours a people of powerful warriors and conquerors, with a rich literature, a people with whom we had tremendous fights, but with whom we nevertheless had long periods of fraternal intellectual intercourse. In the meantime, in spite of that, our own characteristics were all the more thoroughly confirmed, and our language was all the more completely individualised, maintaining itself as the Portuguese language, truly Portuguese, and keeping itself unaffected by any influence from our neighbours.

This tenacious resistance, the evidence of a powerful vitality, is all the more remarkable, as there are great analogies between the two languages.

In conclusion, even among the cultured classes this external influence was not much felt; there is no need to mention the bulk of the people, as they are constant, tenacious and vigorous guardians of the foundations of the language, as well as of the nationality itself.

DR. THEAL AND THE RECORDS OF SOUTH-EAST AFRICA.

BY

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Read July 13, 1922.

Looking up Dr. Theal's Records of South-East Africa once more, in connection with Sir H. Johnston's expressed expectation of philological remains of that historian, it occurred to me that some knowledge of comparative Bantu philology is just what we need in historians of South Africa. I was speaking to one of these not long ago, who mispronounced Bantu names consistently, making it almost impossible to recognise them. Yet, working on the early Portuguese records, I was convinced that a knowledge of Bantu philology, brought to bear on the place names therein occurring, would throw a flood of light on the history. We need a critical edition of these records, with reference to the original MSS. Take Dr. Theal's edition of them, which have done such splendid service in their time: in Vol. I., pp. 58—60 (1898), the personal name of one of the Monomotapas appears in the Portuguese as Quesaryingo, Quesarimgo, Quecarynugo, Quecarimugo, Quecarinuto, and Dr Theal's English gives the further forms Kwesaringo, Kwekarimugo, etc., though the prefix is rightly Bantuised by him in the case of Quiloa (Kilwa) on a previous page. Probably a re-examination of the MS. by someone expert in comparative Bantu would clear up the difficulty. It may be said that the name of a Kafir Chief does not matter, but it will hardly be an historian who says so, seeing that similar difficulties are thickly strewn over these records.

Dr. Theal, that veteran scholar, whose recent loss we deplore, expressed his belief that Oriental sources also would be found to produce a mass of evidence in Arabic, Swaheli, etc., bearing on the history of Africa, if only these could be searched for, but there, again, the Bantu comparative philologist would be needed, as well as the Oriental scholar. In recent work on the early geographers, that has certainly been my experience. Such kind of work should be in a high degree ancillary to African history, yet we have almost none of it at present, and it is work that can only be done by comparative students of Bantu and Semitic, etc., whom at present, so far as South Africa goes, we can number, I might almost say, on the fingers of one hand; and until the public mind gives more encouragement to this branch of research, that state of things is likely to continue.

One reason is the enormous width of the subject of Comparative Philology, even in regard to African languages (the Bantu and Semi-Bantu alone now reach nearly 300), and its practical incompatibility with a really complete and perfected study of even one language in all branches of its comparative literature. Yet we hear academics, blamelessly qualified to teach the classics, or some one modern language, with all the aids which centuries, nay millenia of study (in the former case) may

give, talking airily of difficult native languages (most still awaiting the attention of the expert linguist) and of their comparative philology into the bargain, as a very light thing.

In gauging the advance of Bantu comparative philology, which is the subject of the present writer, we learn the reassuring fact that now there are many excellent authorities on individual dialects, or even groups of them, but the popular mind does not seem to realise that this is not the same thing. It is as though, in the Aryan sphere, any student of French or German were imagined to be a Brugmann, or, on the other hand, the professor of Aryan philology were required also to teach, as a par-ergon, Portuguese, Russian, Welsh and a few other tongues as well.

Returning to Dr. Theal and his South-East Africa Records, it is necessary to recall the course of his life. I learn from his family that the late Dr. Theal left St. John, New Brunswick, in 1859 for Sierra Leone, at which place he spent two years. From there he worked his passage to Port Elizabeth. Then he walked to Knysna where he opened a school. His object in going to Knysna was that he was told that he would get a good knowledge of Dutch in that district. Then he walked from Knysna to East London, at which place he also opened a school and edited a newspaper. Next he went to Kingwilliamstown. At all these places he was gathering information in the hopes of some day writing a South African History.

After these varied efforts to instruct himself and others in the history and possibilities of Africa, which were to merge into his life-work, he had the opportunity of service as a government servant, in magistrate's work, and finally as historiographer at the Cape and Keeper of the Grey Collection.

This work at the centre of things was interrupted, in the inconsequent way our changing Governors had in those days, with their imported, but not always enlightened, values of utility, by Sir Gordon Sprigg; but happily that breezy Providence, Cecil Rhodes, turned the curse into a blessing, by maintaining Dr. Theal in Europe, studying at various libraries.

On the death of Cecil Rhodes, the work practically ceased for a time, because there were no private funds. Rhodes wanted him to go to Egypt. His own desire to search in the East has been referred to above.

My aim in this short paper is, I think, one needing to be emphasised: it is to show that Governments and others, who have the appointment of men to work at very special research, should be patient, and not hastily interrupt that work. It is very possible that some may be found to say of Dr. Theal, as was apparently thought by Sir Gordon Sprigg, that a better man—or one who would suit them better—might be found for such a post. It is nearly always possible, especially for those whose main interest is elsewhere, and to whom perhaps the research in question is not a familiar subject, to conceive of one who would be, ideally, a better-trained researcher, but fact is a hard master, and history a critic full of irony. The fact is that we have been living ever since on that work of Dr. Theal, which the authorities of the time did not, apparently, think it worth while to continue. Ideally, no doubt, Portuguese students should

have produced the South-East Africa Records, and this would, of course, have made the work more valuable from many points of view.

How much easier it is to imagine betterment than to procure it, and how much wiser are they who use patience with the means they have, and encourage their workers who have already given much time and care to making themselves as efficient as they can through years of research in a wide matter such as South African history! Not only has no one done Dr. Theal's work better, but no one has continued it, no one has even re-edited it, while everyone has built upon it in this department, as Prof. Walker, I think the latest worker, frankly acknowledges for his own part in notes on the map of Portuguese East Africa and native migrations.

And how wonderful a vista of history even the mere collection and translation of these records, through the care of the Doctor, has opened up to the English reader! No modern historian's description could equal the heartrending tales of shipwreck, authenticated by survivors, which again and again meet us in the pages of the South-East Records. And these we have every reason to remember at Lourenço Marques, where the weary journeys of lost seamen and passengers, after many thrilling escapes, so often ended; ended sometimes fatally so near to port as Inyack across the Bay. Who shall match the thrill of those moments, when the nurse upon the sinking ship holds up the child the mother in the boat yearns to save, though the condition the nurse makes that she also must be saved is an impossible one for the over-crowded boat? Or where Manuel da Sousa, unhappy nobleman, has to turn his back upon his half-caste son.

Or again, where, in the record of great spiritual enterprise, fraught with large issues to the civilisation of a sub-continent (issues—alas! we must confess it—grievously disappointing) shall we find a match to that most tragic story of Don Gonzalo, of triumph in martyrdom, and yet (through the unworthiness of successors, we cannot help feeling, yet who shall judge in the tangle of history?) martyrdom in some sort in vain? But we may not do more here than refer you to Theal's 2nd volume for that heroic adventure of a lofty, perhaps too other-worldly soul —but again it is hard to judge heroes: every stage in da Silveira's career is an epitome of great-souled devotion, till the day when the Monomotapa's minions did him to death in the present Mashonaland. It is easy to say that anthropology would have saved the Jesuit Missions and others some mistakes in dealing with the Native, but the science was in embryo at the time, and has hardly yet come to birth. (Our first South African Professor in the subject has but just been appointed.) Easy it is to be wise after the fact!

Now all this treasure would be lost to English students, at least, were it not for Dr. Theal: let those who spurn the rungs by which the ladder of knowledge has been climbed say why, since his publication, they have not provided better work. And let those, who are ready to build his sepulchre as a prophet, remember how ready the powers that be were to kill, not long ago, that prophet's work, and to maim his opportunities.

THE EARLY HISTORY OF THE CAPE PROVINCE, AS ILLUSTRATED BY DUTCH PLACE NAMES.

BY

C. Graham Botha,

Keeper of the Archives, Capetown.

Read July 12, 1922.

In the last few years a great deal of interest has been taken in that fascinating study, Place Names. The student of this subject in relation to South Africa must be grateful to the Rev. Chas. Pettman, one of the members of this Association, who has devoted a great deal of time to it. He has not only contributed to the papers read before this section of the Association and to various magazines, but has recently given us in pamphlet form his " Place Names in the Orange Free State." If he will permit me, I would like to call him the " Father of Place Names in South Africa," for I really think he is the pioneer in taking up this inquiry and has inculcated in some of us a desire to assist and add our quota to a subject which is of never-failing interest.

When lecturing in public on South African historical subjects I have frequently touched on the point of Place Names in this country and pleaded not only for their retention but also for their correct spelling. Too often we find farm names which date back to two centuries ago, and maybe have some history attached to them, being changed to some modern, I was almost going to say meaningless, names. What I would like to see is that Place Names which have stood the test of time, whether they be of Portuguese, Dutch, French, German, English or native origin, may be retained. We can rest assured that both native and European of the centuries ago had some reason for naming a place, and this reason, if we could but always know what it was, would enlighten us concerning the surrounding history of the place. It is for this reason that I maintain that the original name should be kept and not altered to some fanciful one. In the case of a disagreeable name, or one which has come to be regarded as vulgar with the passing of years, this objection naturally does not apply. For instance, I do not desire to make anyone live on a farm called Stinkfontein, a name given to many farms in the Cape Province.

In glancing at the map of South Africa we see place names derived from a variety of European and native languages. They tell us something of the history of the country. Many of the

early Portuguese names, for the most part on the coast line, have disappeared and translations of such names are substituted. Here we have the history of the first discoverers. We find the greater number of inland place names of Dutch origin. Many of the early native names were translated by the Dutch into their own language. Here we find the history of the native and Dutch. Take a glance at the place names in the Eastern Province; are not a great number of the English town and farm names reminiscent of the 1820 British Settlers? A number of the German town names remind us of those who came out with the German Legion. And so we could go on, taking large areas or dividing these into small sections, and we should be sure to find place names which will at once suggest something of their origin.

In this paper I want to deal with some names which will recall the days when the Dutch were in possession of the Cape from 1652 to 1795 and again from 1803 to 1806. Although the Dutch were here for nearly a century and a half, few of the names of their governors and statesmen have been given to places. It is to be expected that the name of the first Dutch commander would be commemorated. This is so, for *Riebeeck Kasteel* in the Piquetberg district was named in 1661 by an exploring party which Jan van Riebeeck sent out. *Riebeeck West* and *Riebeeck East* are names given during last century, but also in his honour. Some might suggest that Capetown, the mother city of the country, should have honoured him by taking his name. Would it surprise some of you if I told you that when Commissioner de Mist was here from 1803 to 1805 the idea was mooted that Capetown should be called Riebeeckstad? Simon van der Stel, Governor from 1679 to 1699, gave his name to *Simon's Bay*, from which the town at a later period took its name. His memory is retained by the places *Stellenbosch* and *Simonsberg*, the latter a mountain near French Hoek. In 1687 van der Stel, together with some officials of the Dutch East India Company, made a survey of this bay when it received its name. It had before this been known as *Isselstein Bay*, named after a ship of that name which called there in 1671. It was not until 1742 that Simon's Bay became a port of call for ships, which were obliged to sail into it between the months of May and August when they were secure from the north-west winds. The following year a station with store, hospital and dwellings was established here. In the course of time a small village sprang up, which became known as Simons Town.

In November, 1679, within a month of his arrival, van der Stel visited the place where the town of Stellenbosch stands. Here, in the valley, he saw a clear stream of water which divided at one point and joined again a little further on, forming an island of some size. His party rested on this island, which was dotted thickly with a grove of fine trees. In Dutch the latter was a *bosch* or wood. To perpetuate his name he coupled that of this grove to it, hence *Stellenbosch*. This town is the second oldest town in the Cape Province, the district taking its name from the

town. Capetown (and district) is the oldest. The third oldest town (and district) is *Swellendam*. It was called after Governor Hendrik Swellengrebel and his wife, whose maiden name was ten Damme. The district was founded in 1745, and the village a year later. While the name of a third Dutch Governor is perpetuated, it was not until nearly half a century after his death that the district was so named. I refer to *Tulbagh*. Ryk Tulbagh was Governor from 1751 to 1771, and in 1804 Commissioner de Mist cut off a portion of the district of Stellenbosch and named it in his honour. When the first Europeans saw what is now the *Tulbagh Basin* in 1658 they described it as a plain "four days' journey broad." In 1699 Governor W. A. van der Stel, son of Simon, named this area the *Land of Waveren* in honour of a well-known Amsterdam family to which he was related. By that name it was referred to for a century. The fourth oldest town and district, *Graaff Reinet*, was called after Governor Cornelis Jacob van der Graaff and the maiden name of his wife, Reinet. The district was named in 1785. The site of the drostdy or magistracy, now the town, was that of two farms belonging to one Dirk Coetsee. He received £530 as compensation for the buildings on them and accepted land of an equivalent extent elsewhere. The town and district of Uitenhage is the fifth oldest in the Province. In 1804 a portion of the Graaff Reinet district was cut off and a few months after the Dutch Governor-General Jaussens gave the name of *Uitenhage* to the new area. This was in honour of Commissioner J. A. de Mist, who had been sent to the Cape to receive it on behalf of the Batavian Republic from the hands of the British. The name was a family one of de Mist, who was permitted at a later date, in 1817, by King William of the Netherlands, to resume the full family name of Uitenhage de Mist. One more name recalling a statesman: The *Drakenstein Valley* and *Mountains* in the Paarl district take their name from a high Dutch official, High Commissioner Hendrik Adriaan van Reede tot Drakenstein, Lord of Mydrecht, who visited the Cape in 1685. Simon van der Stel gave this place name in 1687 in his honour, when he settled the first Europeans along the banks of the Berg River, which flows through the valley.

As we look round the coast line of South Africa we still see some Portuguese names, and many which are now Dutch are translations of early Portuguese ones. *Dassen Island* was named in 1601 by Joris van Spilbergen, but four years later received from Sir Edward Michelburne the name of *Coney Island* because of the great number of conies found there. This was subsequently translated by the Dutch into Dassen Island, a name it has retained. *Table Bay* was visited by the Portuguese, Antonio da Saldanha, who called it after himself, but the Dutch seafarer, Joris van Spilbergen, gave it the name of Tafel Baai (Table Bay) in 1601. *Hout Bay* or Wood Bay, was so named in 1653 in consequence of the thick forests which grew on its shores. The well-known seaside resort *Muizenberg* owes its name to a Dutch military officer Muys, who was stationed there before the middle

of the 18th century. It was then an outpost of the Dutch East India Company, and Sergeant Muys, as he was then, was at one time placed in charge of the military there. The records of 1744 refer to this outpost as *Muysenberg* and a few years later as *Muysenburg*. Formerly the mountain close by and the post itself were known as Steenberg. *Kalk Bay* or Lime Bay is marked as such on a chart of 1687, at which time there was a lime kiln. The names of shipwrecked vessels are commemorated along the coast line. For instance, *Oude Schip*, to the north of Hout Bay, recalls the wreck of a Dutch East Indiaman, and *Schoonberg Bay*, near Cape Agulhas, is named after an Indiaman of that name which went ashore there in 1722. Near this part of the coast is a place *Zoetendals Vlei*, which was named after the ship Zoetendal wrecked in 1673 on the coast near by. *Mossel Bay* was called so by Paulus van Caerden in 1601 because he could get no refreshments here except mussels. It had been named *Agoada de Sao Bras* by Vasco da Gama in 1497. The same Dutchman gave the names to *Vlees Baai* and *Vis Baai*, now translated into English as *Flesh* and *Fish Bays* respectively. The first was so named because the voyagers were able to procure from the natives for pieces of iron as much horned cattle and sheep as they could consume or could preserve. At Fish Bay he and his companions caught an abundance of fine fish and thus gave the place its name.

A great number of river names were given by the early Dutch, but several have been Anglicised. In 1760 a farmer, Jacobus Coetsee, Jan's son, lived near Piquetberg and obtained permission from the Government to hunt elephants. He set out with a wagon and twelve Hottentots, and passing through Namaqualand arrived at the *Groot* or *Great River* called by the natives *Eyn*, and at first by the Dutch *Vigiti Magna*. It was believed that this river had never been forded by Europeans before. In 1779 Colonel Robert Jacob Gordon, in the service of the Dutch East India Company, called this river the *Orange River* in honour of the Prince of Orange, a name it has since retained. In 1657 an exploring party sent out by van Riebeeck named the *Berg* or Mountain River because when they came upon it after passing Klapmuts they saw it running northward along the base of an almost impossible chain of mountains. Ten years later another party found on the banks of a river a Hottentot tribe called the Gouriqua and called it the *Gourits River*, which name it has retained. As the Dutch East India Company extended their possessions at the Cape they affixed beacons or *baakens* to denote the boundaries. At the mouth of the *Baakens River*, near Port Elizabeth, they erected such a mark, hence the name of the river. The derivation of many place names is evident from their meaning, and especially when we know the surroundings in which such places are situated. *Breede Rivier* or Broad River explains itself. *Kromme Rivier* deserves the name as its course is full of bends and curves. In 1660 Dutch explorers to the north-west of the Colony came to a river in which they saw a herd of two to three

hundred elephants, hence they named the river *Oliphants Rivier.* The *Liesbeek* in the Cape Peninsula is a river name given in the days of Jan van Riebeeck.

In looking through the journals of the early explorers in South Africa we can gather the origin of many place names. The town of *Paarl* takes its name from the huge rock on the top of the mountain close by. In the days of van Riebeeck the first explorers saw in the distance in the early morning this large boulder shining in the morning sun. They called it *Diamandt en Peerlbergh,* Diamond and Paarl Mountain. In the diary of Simon van der Stel's trip to the Copper Mountains in Namaqualand in 1685 there are many place names mentioned which exist to-day. *Honigsberg,* Honey Mountain, in the Malmesbury district, was so called by these travellers because they found an abundance of honey. They crossed *Misverstand Drift*, and when near the Piquetberg Mountains an incident occurred which gave a place name. A rhinoceros sprang out and charged the carriage in which van der Stel was seated. He just had time to spring out, but was followed by the animal, which received a bullet from one of the party. It turned its attention to a party of horsemen, who leaped from their saddles. The beast rushed away, followed by a volley of shots. This place was consequently called *Rhenoster Rug.* Shortly after an eland weighing one thousand pounds (Dutch) was shot, and the locality was given the name of *Eland's Kraal. Uilenberg* and *Dassenberg* were named on account of the many owls and conies or rock rabbits found there. The party passed *Baviaansberg* (Baboon Mountain) (Clanwilliam district), which received its name on account of the number of baboons living in the caves. Following the windings of the Oliphants River, the train arrived at *Bakkeley Plaats*, where a fight took place between the Europeans and natives, and a little further on the locality where peace was made between them was called *Vredendal* or Vale of Peace. An expedition of 1667 named the *Lange Kloof* or Longkloof (Oudtshoorn district) on account of its great length.

The fauna of the country has given a large number of names in the country. This adds an interesting aspect to the study of place names, for we see that with the advance of civilisation the wild animals were made to retreat further and further from their usual habitat. In many places the animals have ceased to exist, yet the place names referring to them remain. Names referring to the lion, elephant and rhinoceros are found within a radius of one hundred miles of Capetown, but these animals had disappeared from this locality many generations ago. In glancing at the farm names of the old Cape Colony we are at once struck with the great frequency of names referring to the eland and the buffel. In fact, I may almost say that they occur in greater numbers than any other. The lion, elephant, hartebeest and hippopotamus appear to come next on the list. Few places seem to relate to the gemsbok. And so one could take both the name and locality, and deduce the fact as to where certain animals

were found and by the frequency of the name that they abounded in large numbers.

We are impressed with the number of farms which bear the same name, not only in various parts of the country, but even in the same district. Names such as *Keerom*, *Keer Weder* and *Omdragi* or Turn Back occur several times and are especially situated at the foot of some mountain barrier. This is indicative of the difficulties the early pioneers had of crossing the mountain. Names referring to a murder are found in various farms and many districts. For instance *Moordenaars Kloof*, *Moordenaar's Hoek*, *Moordenaars Kraal* and *Moordenaars Berg* and other forms are found. Places relating to the Dutch East India Company are of frequent occurrence, such as *Compagnies Post* or *Compagnies Drift*. In several districts of the Western Province will be found a hill or eminence called *Kanonberg*, Cannon Hill. This is very interesting, as it reminds us of the signal stations on which a cannon was placed and fired off in order to call the burgher militia to arms in time of danger. On several of these hills the old cannon are still to be found. Here is certainly a place name which should be preserved.

This fascinating study of place names could be extended in various directions. Many more examples could be given, indicative of the early days, but these brief notes have been given only to show what a wide field there is for those who desire to take up this line of research.

AN INTRODUCTORY OUTLINE OF SOME OF THE PRACTICAL APPLICATIONS OF MODERN PSYCHOLOGY.

BY

F. S. LIVIE-NOBLE.

Read July 13, 1922.

A few prefatory words are necessary to explain the origin, character and purpose of this paper.

Its origin is due to the intense importance of the subject, but also to the fact that, on looking through our schedule of sections and subject, I was unable to find the word Psychology anywhere used. One possible explanation of this omission seemed to be that the subject was not considered of sufficient importance to merit notice—as indeed has been the view of the authorities of more than one University until quite recently. Since I believe that it is a subject of more than academic interest, I have presented this paper.

The paper claims to be nothing more than an introductory outline, and that fact—together with the demands of brevity for printing—has caused me to omit many examples, references, and all authorities (except one).

The subject is to be regarded not as a sub-section of other studies, or the subject of a few " cranks," but rather as a general foundation upon which to build other studies. This paper does not profess to deal with psychological research, much less with the history of psychology as a whole.

Psychology is a real and vital subject; and, in as much as we are each possessed of much more than a physical structure and automatic activities, psychology means much to us—in fact, just as much as we are willing to allow it to mean. In all the activities of life in which something more than chemical action and automatic response is required, there psychology will have some help to offer us. Therefore, I shall aim at fostering discussion on the suggestions of utility which will be raised. I hope to arouse interest rather than to satisfy it here; to encourage my readers to study the subject rather than to make mere dogmatic assertions.

A word must be said about the psychological viewpoint which is adopted in this paper. The old school of psychologists regarded their subject as " the Science of Mind," and accordingly they delved into the processes of reason, mental energy and memory; and before long they had invaded the realms of philosophy. I even think that some of this old school tried to define " Mind "—a task pre-eminently for the philosopher and metaphysician.

There is, however, a new school of psychologists who regard their subject as the "science of behaviour": they deal chiefly with considerations of the emotions and sensations of the human being. It is probable that this school arose through the increased interest in sociology and the enforced study of war-neuroses and of abnormal behaviour in the individual and the herd. These Behaviourists, as we call them, would seem to pay more heed to the physiological changes in the individual than to the specific mental and psychic causes and effects of such changes. Undoubtedly there must be many changes of the organism which are unobserved, and the interesting question arises as to how far, if at all, such unobserved changes can affect other people, and so be called "behaviour." This point is still very much in dispute, but we cannot deal with that controversy here. The Behaviourist School, in their very much simplified and therefore inadequate system, do away entirely with what is generally known as the Sub-conscious; but this is a factor of great importance in the work of the other schools—as will be seen later. A middle school between the two mentioned above regards psychology simply as the study of human mental reactions in the individual, and its task as the collation and comparison of its observations in this direction. The *method* of study chiefly employed by the old school was that of introspection—looking within themselves to gauge and classify their experiences and sensations, and to determine by this same means the stages and processes of rationalisation and thought. Although this method did, indeed, teach them a considerable amount, yet for obvious reasons it was untrustworthy. Not always was the older psychologist able to remember that when he was introspecting he was looking within a psychologist; and no one was likely to adopt the science who had not a certain distinctive type of mind and taste—a factor which it was not always easy to eliminate when casting general principles and empiricisms. Perhaps the most important and most promising method of research conducted at the present day is that which is known as "experimental psychology." By this must be understood not a modern school who differ from the stable middle school mentioned above, but simply the method of those who have adopted laboratory work as a complementary means of study. This laboratory work may roughly be classed under two headings: (a) physical—the study of sensations, etc.; (b) mental—the study of the degree of acuity of apprehension, memory-span, etc. Of the actual technique of the experimental work and of the variety of special apparatus employed, though of great interest, we cannot write at present.

It is claimed that by means of this work the degree of mentality, sensibility to stimuli, and manual dexterity can be measured and classified; and if this claim be justified it follows that practical applications of these methods should be useful in every occupation where such factors are of importance. That this claim is justified we shall briefly endeavour to show.

It is obvious that in the course of a very limited paper, and especially when dealing with a subject of universal application,

selection rather than extensive statistics is demanded. The three outstanding directions in which practical applications of psychology have proved of inestimable benefit, and which therefore have been chosen as examples for our present purpose, are the realms of Medicine, Education, and Industry.

Medicine.

Space only permits of a brief synopsis of this section.

The outstanding effects of psychological research on medical practice are most obvious in the recognition of the fact that many common ailments as well as obscure functional disorders are due to purely psychic causes; in the facilitation of the diagnosis of neurotic and psychasthenic cases by the employment of mental analysis and hypnosis; in the scientific use of suggestion in the effective stimulation of affected nerves; and in the development—by autognosis—of a sane outlook on the media of shocks and fears.

The War, which brought to the fore the mis-styled "shell-shock," also saw the appointment of consulting psychologists to study and treat that disorder. Many of its phases were recognised as identical with conditions met with in civil practice, and psychiatry has consequently been increasingly used since the War. Psychological methods of diagnosis have been responsible for saving more than one man in the army from a coward's death, and very many from the false charge of malingering.

Hypnotism and analysis have been very fruitful in tracing original causes of disorders, such as infantile shocks and fears which—through adverse circumstances—have presented themselves in the form of amnesia, hysteria, paraplegia, etc., possibly including also a variety of psycho-genetic epilepsy. The "autognosis" consequent to analysis is possibly the most important factor in the development and retention of mental stability. In the increasing degree of suggestibility of patients, hypnotism holds an unrivalled field; but it is too seldom employed scientifically—although it is very often used, unconsciously, being in fact a *sine qua non* of effective "suggestion." The name is unfortunate, for hypnotism does not imply the induction of sleep; but is a condition of deep involitional concentration of attention: what the Nancy school of applied psychology call "contention."

Perhaps the most important part of the treatment proper of psycho-neurotic disorders may be described by the inclusive title "re-education of the mind." This idea is based on the principle that all disorders of this particular category are due to the inability of the human organism to adapt itself to some particular circumstances or environment which are recognised as the "media" of the disorder. For example, where it is found that an infantile shock has produced some mal-functioning the psychologist emphasises the obvious truth that it was not the "object" (media) of the shock which caused the malfunctioning, but the inability of the organism to adapt itself to the demands of the occasion. The occasion is not the cause. Mental instability can also be produced by undue activity of one process of mentation

at the expense of the rest; for example, in the fanatic and the narrow type of genius.

While psychology is of proven use in removal of anomalies and in the restoration of a "stable mentality," it is also employed as a prophylactic; and this by the correct application of educational processes.

Education.

As has just been hinted before, the value and purpose of true education are to be realised in the development of a stable mentality—at all times assimilative and progressive and withal adaptable. People are so apt nowadays to regard education as simply the listening to lectures and trying to stuff into their brain-boxes as much as they can in order to top the examination-lists. I speak with all seriousness when I affirm that there is no greater curse on true education than the examination system. By it boys and girls, men and women, are encouraged to concentrate their "volitional attention" on the assimilation of facts and formulæ—usually from but some few text-books; while only little, if any, attention is paid to the scope, definition and place of the subject in the affairs and philosophy of practical life. Obviously this applies more to some subjects than to others; but I am humbly of the opinion that there are but few which can claim exemption from the objection.

The old practice of demanding that children should "learn by heart" huge passages of poetry and prose is now fortunately a thing of the past in the best of schools; but the reform has not been carried consistently to the abolition of every form of mnemonics and cramming. The very word "education" means "drawing-out," not cramming-in. When one reads a book, hears an address, sees a vision or undergoes an experience, the objects of those sensations are but the media by which the mind is influenced; "they strike as it were some resonant chord of vital memory, making one realise (*i.e.*, to make real to one's self) that that which one has seen, heard or experienced is real—true—or otherwise.

The *method* of education is also a department in which psychology has caused, and will further cause, considerable revolution. The old-fashioned method of teaching was synthetic. For example, languages were taught from the grammar, through rules of syntax, finally to conversation. This is fast dying out. (Latin, of course, is an exception; for the purpose of learning Latin is largely to understand what a grammar is; but modern languages are learned rather as languages.) So far as I know grammar, in the development of languages, was practically the last stage before their fixation. The child is not introduced to Mr. Nesfield before he begins to talk; but he becomes comparatively fluent—sometimes harassingly so—at an early age, and long before he knows of the existence of grammars or their editors. He starts from conversation, from "Kak-kak," "ack-

ack," "da-da," "ta-ta" (which are most probably purely instinctive utterances) and gradually by imitation acquires a conversational vocabulary, finding out eventually why it is that he says "I was good" in preference to "I were good." So now conversation classes and reading classes have a position of priority in the study of languages, a large amount of grammar and syntax being assimilated incidentally, and perfected afterwards. This more rational method of helping the child to develop along the lines that nature employs is essentially analytic; and an even clearer example may now be quoted. A music-master of my acquaintance had his pupils sit down in a room where they could read or talk as they felt inclined while he set out to entertain them on the piano. He played a variety of compositions, and then drifted into Wagner. At this point he noticed that the boys were sitting up in interest, so he told them what it was that he had been playing. Then he told them a story—the story of Tannhauser. On the occasion of the next lesson they were to hand in what they remembered of the story, written in their own words. At that lesson they were introduced to a definition of music—what it is and what its purpose and value. Almost everyone of the boys evinced no small interest on hearing that music was a "channel" through which feelings, sensations and even thoughts could be expressed. As an example of this "expression" the boys were told to remember the story of Tannhauser, and to say what part of it was represented by the music which was then played to them. A large majority, over two-thirds of them, at once said it was the Pilgrims' Chorus. In these boys the master had developed, drawn-out, what usually takes about three years by synthetic methods, namely, a fairly keen musical appreciation, and that in two lessons! Intelligent interest is the first requisite in the learning of any subject; and psychologists claim that the golden rule by which to acquire this is always to start from an appreciation of the whole subject, then find the definition and scope, and study in an analytic way from the general outline down to minute details. Nor is this method advisable only in the case of languages and the greater arts; for the method has been used in coaching students even in such subjects as Patent Office Law and Practice—with very gratifying results.

The analytic method is perfectly satisfactory even for examination purposes; so long as the pupils are studying their subjects, and not merely "reading for exams." The pernicious practice still unfortunately employed by some tutors and coaches of setting "spot questions" for examination study is one well-calculated to destroy any mental ability which the poor student has; while the tutor who sets his pupils to work on a text-book rather than on a subject is putting a barrier in front of whatever capabilities there are in the pupil's mind awaiting development. The system of cramming is essentially synthetic: the psychological process of education is essentially analytic.

If it be urged that the old-fashioned drudgery had a great moral value, inculcating a devotion to duty and routine work, it

must be said also that it is hardly fair to jeopardise a boy's real education by employing unsound methods in the hope of a moral improvement, especially when all the moral training, *esprit de corps*, initiative can be much better developed by such means as compulsory games, physical training, cadet corps drill.

It would also seem that psychology is going to solve the vexed question of the method of imparting sex-instruction in the home and in the school. Space forbids me to dwell on this, beyond saying that the method is again an analytic one-starting from the universality of sex and leading through elementary biology and zoology, on to human special reproduction. Among other pressing subjects in which practical applications of psychology are of proven value may be mentioned, the diagnosis and cure of religious scruples, morbidity; the method of native education (on which Dr. Loram's book is a masterpiece); and the reform of religious instruction of aboriginal people; and the vocational training of youth.

In general education, further evidences of the value of practical psychology are seen in the inculcation of positive instruction and discipline in place of the antiquated " negatives," re-arrangement of the order of subjects in the time-table to minimise fatigue, and allocation of the recreation time so as to revitalise the fatigued mind. Discipline is being inculcated by a greater trust of the pupils to do what is required, not to avoid doing what is wrong: a wider freedom—freedom to use all their powers in doing something positive, and a consequent higher sense of honour. Sportsmanship, good-form, gentle-manliness become more real forces as this wider aspect of discipline is taught.

Towards the end of his school days, the boy will have to think about his future career. Some have their profession chosen for them; the talented and the genius soon realise their vocation; and family tradition often decides the question. But there are many to whom the lure of a big salary, the advice of well-meaning friends, boyish hero-worship, are disastrous. They find themselves in uncongenial or " blind-alley " occupations. Much time is wasted by those who must wander from one type of work to another seeking their vocation, and by the poor employer who must try to train many unsuitable candidates. There are a great many youths even at our South African Universities and Colleges, who have no idea of the kind of profession which will suit them, and not a few find that they have misused three years in " studying examination subjects " which they will drop as soon as they leave college, and from which little or no mental development is effected.

Experimental psychology has made it possible for the sensibility and mentality of each person to be measured: and if the methods of this science were utilised this wastage of time, money and youth would be stopped. Such methods are known as vocational tests; and they lead us naturally to the brief consideration of the applications of psychology in later life.

Industry.

A good deal of the matter in this section is from the conversations and lectures of Dr. C. S. Myers, of Cambridge, and much of it is contained in his " Mind and Work " published subsequently.

The managers of large factories continually complain about the number of men who wander from one department of the works to another, or from one factory to another. Statistics on this migration were first taken in America, where it was found that, at one factory, only 10 per cent. of the 10,000 men who left the works during a certain period did so for reasons known to the employers. Obviously very many of the other 90 per cent. migrated to find more suitable or congenial work. Wastage to both employers and employed is therefore enormous. The same complaint is heard, not only in America, but also in the Midlands and the iron and steel centres of the north of England. As we have said, the chief cause of this is that so many men do not know the kind of occupation to which they are best suited, nor in what their interests lie. Other factors causing men to be dissatisfied with their work, such as unhealthy conditions of labour, " rushing," etc., need not trouble us here; for in England these matters are under the careful eye of H.M. Inspector of Factories; but it is the chief cause—the wastage of talent and the unsuitability of many employees for their particular occupation—which we are considering, and the right methods by which to find the right man for the right place.

If we might adapt the old motto, we should say that the employers' aim should be to have " a place for every man, and every man in his place." In each type of occupation it is seen that some men succeed much more than others; and this is because the abilities and tendencies of men differ. " In some the constructive instinct predominates, in others the acquisitive, in others the meekly submissive." Again, the hunting, agricultural and aesthetic types are all different; and their concomitant instincts and tendencies are the outstanding marks of the respective type. It is also seen by experimental study that there are great differences of apprehension-span and memory-span, manual dexterity, acuity of hearing, numerical memory-span, etc., all of which have their part to play in different occupations. For example, in a pencil factory, manual dexterity is necessary to pick up exactly a dozen pencils at a time; and only those should therefore be employed at this who can readily be trained to pick up the requisite number without having to count them every time. Telephone operators, machinists, typists, moulders, builders, and all other kinds of workers are called upon to use some special ability or other in their work, and these characteristics and abilities are measurable by means of experimental tests such as are now employed in the National Institute of Psychology and Physiology in Britain. The condition of having a round peg in a square hole could easily be avoided if such tests were used in judging the individual capacity of each applicant for each type

of position, such as was done to some extent in the Air Force and other branches of the Forces during the War.

As an outstanding example of the great influence of these psychological studies on factory life may be mentioned the big changes brought about by "fatigue-study" and "motion-study." It was noticed that considerable time was lost, output kept down, fatigue increased and dissatisfaction resulted from the unnecessary bending about of a machinist at his bench to get the appropriate tools for his task. The motions necessary for that particular occupation were closely studied, and the tools were arranged in a case in front of and above the bench. Unnecessary bending was thereby avoided, fatigue minimised, and manual operations facilitated, while the output was increased and the workman more satisfied with his consequent higher wage for more results. The arrangement of the tools is reached in the same way as the arrangement of the keys on a typewriter. Those more frequently used are most accessible, and the sequence is closely studied. It should also be noticed that "fatigue-studies" have revolutionised the arrangement of time-tables in factories as in schools. Shorter periods of work, more frequent short rests in those occupations where this is possible, are proved to produce greater output and increased interest, and consequent higher satisfaction. It is also proven, I think, that "rushing through" and "overtime" will be avoided by the employer who considers the efficiency of his workmen.

It may not be out of place to direct our thoughts at this time to the prevalent industrial unrest in the world. It is possible that a large part of the cause of this is to be found in the strain of the years of war; but the general natural wish for self-improvement, the clamour for knowledge and power, the need for a fair wage-basis, etc., are also largely responsible. There can be no denying that in the past many instincts have been bottled up within the labourer. He was regarded as an automaton, set to do a certain task with little or no intelligence required in its performance. Employees are often to be found who neither know nor want to know the purpose of the works in which they are engaged. As soon as they finish their work they know that they will receive their pay, and so be able to provide for the meagre requirements of their families. They are too often regarded as mere machines, fed by a weekly wage in order to produce a certain amount of work; but the time for this is now past—at all events for the European. The instincts which have for generations been bottled up are now pushing their way to the front of the workman's mind; but their actual presentation is often an inversion of the original instinct. Both employers and employed really know that they are not themselves without blame; but they refuse to recognise the facts. For long years masters have underpaid their men, made them work for long hours in unhealthy conditions, and turned a blind eye to their social and family life; while, on the other hand, generations of hard living have produced in the workmen mental instability, sensitivity, and

erratic work. Thus by inverse presentation the workmens' troubles seem to be perpetual slighting and unfair treatment. But it is really because he has a sub-conscious distrust of himself that he distrusts his employers—and his own union representatives!

The psychological studies of which we have been thinking are not very favourably received by either employers or employed in England at present; and the reason for this is the same as for the distrust mentioned above. Motion- and fatigue-studies are complex, and take time; and even psychologists have to be paid. The employers are often too short-sighted to see the advantages which will accrue to them; and they are often conservative. Especially is this the case with the "self-made" man. Having passed through those workshops himself as a boy, working from early morn to late at night for a quarter of the wages he has to pay his men, he will not willingly consider new proposals which demand even the slightest additional expense. Science is to him as it was when he was a boy in the same workshops—a closed book—the study of cranks. On the other side the men believe that the motion-studies will restrict their reviving instincts and "reduce them to mere machines." They again are also very conservative. It is going to take more than a scientist to teach a man, who has been doing the same job all his life, a simpler and quicker way of doing it. But there are a few places in England where the value of such studies has been proved, as well as in many of the large factories in America; but in order to institute such studies, laboratories and testing-offices are necessary in connection with factories and works.

Since the aim of rearrangement and reorganisation of work is to increase the satisfaction of the workmen as well as to increase and develop industry, then the processes must be carried out gradually, with the full knowledge of the men, and with the endeavour to gain their sympathy and help. A tactful psychological adviser will not meet with great difficulty in getting the confidence of the men, and he will learn much from their behaviour and experience. The first thing he will do is to seek to arouse interest in the work generally and lead the men to desire improvements. But in this he will have to be supported by the employers and foremen. The first essential in industry, as in any study, is the personal interest taken therein by the individual worker; and this we believe can best be ensured by giving the men an interest in the works as a whole; for example, by having as their administrators and foremen men duly elected by themselves and the employers, together with their own representatives on the Directorial Board. This would possibly do away with the type of foremen, appointed for his "push" and what passes for "authority," who is often a cause of much dissatisfaction in the workshops.

I hope that sufficient has been said in this introductory outline to show the value of practical psychological methods and to emphasise the need for renewed efforts in the building up of

the post-war conditions of life. So far from being the study of a few cranks, psychology can thus be applied to almost every department of life; and one can only view the future with tremendous hope for those countries that are not too conservative to avail themselves of the results of research on these lines. Already in America and in England considerable progress has been made in the three departments we have chosen for our examples; and, because experimental psychology is still in its infancy, there are greater strides still to be made. We feel that in the gradual introduction of the psychological adviser into the realm of industry, where he will be considering the welfare of both employers and employed, lies the solution of much of the industrial unrest; and the development of commerce along sound and humane lines. There is before us a "great door and effectual" opened, with the prospect of industrial peace, general efficiency, and material, mental and moral prosperity such as is not yet realised even in the great industrial America; but for this provision must be made.

Therefore, we plead for the immediate setting up of laboratories and testing-offices in connection with our schools, colleges, and industrial centres, conducted on lines similar to those of the National Institute of Psychology; that the practical experiments of psychology may be enhanced, ultimately to be applied to all the occupations in which the human mind and body are engaged.

A NOTE ON SOME AUSTRALIAN PROPOSALS FOR A WAGE VARYING IN PROPORTION TO THE SIZE OF THE FAMILY.

BY

MABEL ATKINSON, M.A. (MRS. PALMER),

Lecturer in Economics, Natal Technical College, Durban.

Read July 14, 1922.

It has for some years now in Australia been a part of the policy of the community that wages should not be determined by competition but by reference to the reasonable standard of life of the worker. The famous precedent in which this principle is first embodied is the statement by Mr. Justice Higgins, President of the Commonwealth Arbitration Court, who laid it down in 1907 (in the Harvester Case)[1] that the standard to be used in fixing wages must be "the normal needs of the average employee regarded as a human being living in a civilised community." He went on to say: "Surely the State in stipulating for fair and reasonable remuneration for the employees means that the wages shall be sufficient to provide . . . a condition of frugal comfort estimated by current human standards. This, then, is the primary test, the test which I shall apply in ascertaining the minimum wage that can be treated as fair and reasonable in the case of unskilled labourers."

Wages were from time to time fixed on this basis on the assumption that the male adult worker has to support himself, a wife and three children. The first rate fixed was 7s. a day, but as prices increased in Australia, as in all other countries as a result of the war, the minimum had from time to time to be raised, and in 1919 the Federal minimum basic wage had been established at £3 17s. a week.

It was, however, asserted by many workers, and the employers did not dispute the assertion, that this wage was not adequate for existence on a civilised basis for the supposed standard family of five persons. The Government Statist of Tasmania, for example, in an independent inquiry ascertained that £6 a week was necessary in Hobart for the family named,[2] and a Hobart employer gave it as his opinion that a man with a wife and three dependent children "must be having a rotten bad time of it" if he had to bring up his family on the existing basic wage of £3 17s. a week.[3]

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[1] Commonwealth Arbitration Court, 1907.
[2] Second Report of Basic Wage Commission, p. 107.
[3] Evidence of President of Hobart Chamber of Commerce, Aug. 25, 1920.

In the General Election in October, 1919, the alleged insufficiency of the wage was brought to the notice of the Federal Government, who undertook to find means to adjust the minimum wage automatically to the cost of living, in order that a wage should be paid such as would enable a man to marry and bring up children in a decent, wholesome condition. This Commission, entitled "The Basic Wage Commission," was appointed in December, 1919, and consisted of seven members, three nominated by employer organisations and three by employee organisations, with Mr. A. B. Piddington, K.C., as chairman. This Commission took exhaustive evidence on the necessary standard of living required by the worker in accordance with the Australian civilised minimum standard, and also on the cost of providing this necessary minimum. The finding deals, for example, with the rents of houses, with the amount of clothing required, with the cost of food, and with various miscellaneous items, including union dues, medicine, domestic assistance, recreation, amusements and library.

To a reader not accustomed to the high Australian standard of living the different items seem certainly calculated on a somewhat generous scale. For example, the house is to be a five-roomed house in sound tenantable condition, not cramped as to allotment, situated in decent surroundings and provided with bath, copper and tubs. In Melbourne the rent of such a house was £1 0s. 6d. a week.

The Commission even went into such details as the amount and quality of clothes required by the wife. She was, for instance, to be provided with two best hats to last for two years, and another to last one year, a winter and summer costume, both to last three years, a silk blouse to last two years, six handkerchiefs a year, one pair silk and one pair cotton gloves a year. Of all these items the cost in November, 1920, was estimated at 10s. 9d. per week.

As a result of these elaborate investigations, the Commission decided that £5 16s. a week was the necessary basic wage for providing a minimum standard of civilised comfort. This, it should be noted, is not a recommendation that such a wage should be paid. It was merely a statement of two facts: (1) that to attain a minimum standard of comfort, certain commodities must be provided, and (2) that the cost of these commodities was, in November, 1920, for a family of five persons £5 16s. a week. Nevertheless, the finding, indicating, as it did, a very marked increase on the minimum wage (which industries were already finding it difficult to pay), resulted in widespread dismay. It would have been extremely difficult for the employers' organisations who were represented on the finding to assert that a standard of comfort lower than that taken should be established, and it could not be denied that this standard could not be attained except on the expenditure stated.

On the presentation of the report, the Prime Minister obtained from the Commonwealth Statistician, Mr. G. H. Knibbs, C.M.G., a memorandum on the feasibility of paying such a wage, and the Statistician asserted, without any hesitation, that the

entire wealth of the country would not be adequate, if divided amongst employees alone, to yield the necessary amount. It was also pointed out that the payment of such an increased wage would necessarily result in a further increase in prices, a further rise in the cost of living, and a still further necessary increase in the minimum wage. The Prime Minister, therefore, sent for the Chairman of the Commission to discuss the question with him, and the Chairman as a result of this conversation presented a memorandum for which he alone was responsible, there not being time to consult his colleagues. In the course of this memorandum he pointed out that, if all employees received a sum necessary to support a wife and three children, there were many cases where they received far more than their actual needs. He produced statistics to show that the childless married and the unmarried constituted 62 per cent. of the male wage-earners, while the married with one child were another 8 per cent. It followed that for 70 per cent. of the population the minimum wage was far more than adequate. But the other 30 per cent. received barely sufficient to support their wives and children. As Mr. Piddington put it, the existing organisation of the minimum wage provided for 450,000 non-existing wives, and for over two million non-existing children.

In order to meet these difficulties Mr. Piddington recommended an ingenious scheme. He argued that each employee must cost the employer an equal amount, otherwise there would inevitably be a disastrous preference of unmarried men and men with small families. On the other hand, it is equally necessary that the man with a large family should receive enough to keep his household in reasonable comfort; yet if all receive the standard of the man with the family the State would be bankrupt. He, therefore, suggested that each employee should receive enough to keep a man and wife (this in order that he might have opportunity during his bachelorhood, which ends on the average for the whole Commonwealth at the age of 29, to save up for equipping the home.) This figure, he suggested, might be fixed at £4 a week, which would be only a slight addition to the existing minimum wage. He then went on to propose that each employer should pay into a central fund the sum of 10s. 9d. per week, and that this should then be distributed out again to the married men at the rate of 12s. per child per week; thus the wage for a married man with three children would be £5 16s. a week, while the obligation on the employer would not be greatly higher than the rate at which the minimum wage was already fixed.

It is clear that this scheme does find a way out of one of the serious difficulties of the wage system. Mr. Seebohm Rowntree pointed out many years ago[1] that so long as the worker had only himself or his wife and one child to support he lived in conditions of reasonable prosperity, but as soon as the family increased all members of it necessarily suffered from demoralising poverty.

[1] Poverty: A Study of Town Life. 4th Edition, p. 136.

Students of the conditions of the unskilled labouring classes have been coming more and more to the same conclusion, namely, that the only way in which industry can bear the imposition of the minimum wage necessary for a civilised existence is by the establishment of a differential scale varying in accordance with the size of the family. In a very different sphere it may be noted that the Wesleyan Church has for long paid its ministers on this basis. A man's salary automatically increases with the number of dependent children.

The Federal Government, while refusing to accept the findings of the report of the Basic Wage Commission or the Chairman's recommendation, announced that in the public service of the Commonwealth steps were to be taken to give to all married men £4 a week with an additional endowment of 5s. per child per week. This was coupled with the announcement that the amount of endowment was not being put forward as necessarily sufficient. Since that time Australia, like the rest of the world, has suffered from a slump, and for the time being the proposals of the Commission and its Chairman have been set aside. Indeed, from the latest telegrams received from Australia, it appears that as far as rural workers are concerned the minimum wage is to be given up. But the difficulty which Mr. Piddington, almost for the first time, had to face on behalf of an entire nation, still remains.

Any reader who faces the problem must admit:

(1) That the wage paid by the employer to every worker doing the same kind of work should be identical, otherwise there would necessarily be a preference for the cheaper worker, resulting in the expulsion of the higher paid one.

(2) That many industries cannot bear the imposition of a wage necessary to supply the full family needs of the man with a wife and three children.

(3) That from the standpoint of the community it is, nevertheless, not desirable that the larger families should be penalised by poverty.

On the contrary, nearly everybody who has studied the question has agreed that any system which leads the more prudent and reasonable of the workers to restrict their families is undesirable.

If these three points are conceded it follows automatically that some modification of the wage system is desirable, to enable a fund for child endowment to be formed. Somewhat similar experiments are being tried by some of the German industries and German municipalities. Mr. Piddington's memorandum is mainly interesting as having laid down on a strictly scientific and statistical basis the needs for such modification, and some suggestions as to the methods by which it would be worked.

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